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THE HISTORY OF A RECENT ASTRONOMICAL DISCOVERY.

BY MAJOR-GENERAL A. W. DRAYSON, F.R.A.S.

To state that an astronomical discovery of considerable importance has been made in comparatively recent times, may probably cause the majority of people to imagine that such a statement must be the result of a delusion, because astronomy, it has been asserted, is the most perfect of sciences, in which there is nothing more to discover. It is curious that this delusion with regard to astronomy has been held at various dates in the past. Four hundred years ago, when it was not known that the earth had any movement, it was yet firmly believed that everything was known. It is a fatal error to imagine that in any science we have arrived at the culmination of knowledge; more especially is this the case in so vast a subject as astronomy.

Having had, what I may truly term, the misfortune to stumble on an astronomical discovery nearly thirty years ago, I will endeavor to describe this novelty in as popular language as the subject admits of, because so many misrepresentations, probably from want of knowledge, have been made with regard to it that the general public have been entirely misled, or fail to have more than a vague idea that something has been put forward by me which is incapable of proof and is utterly contradicted by well-known facts.

88679

The very opposite happens to be the case; that which I put forward is capable of the most exact proof, and is in accordance with facts. During my early instructions in astronomy, I was taught that the earth had three principal movements, *viz.: First.*—A daily rotation around an axis. *Second.*—An annual revolution around the sun. *Third.*—A conical motion of the axis of daily rotation—this conical motion causing the pole of the heavens to trace a circle in the heavens during 25,868 years around the pole of the ecliptic as a centre, keeping constantly 23° 28′ from this centre.

In article 316, Herschel's "Outlines of Astronomy," and in every other book on astronomy, this third movement of the earth is described in similar terms, and it is this third movement which causes the equinoctial point in the earth's orbit to advance from year to year, a fact defined as the "precession of the equinoxes."

I accepted this teaching without question, and never for a moment doubted its accuracy; and had it not been for a peculiar official position I held, it is almost certain that even at the present time I should be a firm believer in the accuracy of the above statement, relative to the third movement of the earth.

One of my duties at Woolwich was to instruct officers of all ranks in every branch of astronomy. Having attended during two years at the Royal Observatory, Greenwich, and acquired a practical knowledge of all the details carried on there, and having studied every book on astronomy that I could procure, I imagined I knew all that was to be known on this subject. The usual relative position of instructor and pupil, where the former states and the pupil without question accepts, did not exist between me and the officers who came to me for instruction. These officers would not accept any statement merely because some authority had said it was so; they would object, discuss, and argue, if any assertion was made without proof of its accuracy being given.

Having on one occasion described to a class of officers the third movement of the earth in the following terms, which will be found in article 316, Herschel's "Astronomy," *viz.*,

that the pole of the heavens described a circle in the heavens, around the pole of the ecliptic as a centre, keeping constantly 23° 28′ from it, I was interrupted by an officer with the remark: "That must be wrong; the two poles do not keep constantly 23° 28′ apart. It is known, and has long been admitted, that these two poles decrease their distance from each other about 48″ per century. Herschel himself, in article 640, states that there is a decrease of 48″ per century between these two poles, yet in article 316 he states that they always keep at the same distance of 23° 28′. The two statements contradict one another; there *must* be something wrong."

I had to admit that the two statements did contradict one another, but I had merely quoted what was printed in the text-book, and that I would thoroughly examine the problem. I little imagined the enormous work I had undertaken, and the difficulties that I should have to surmount when I undertook this examination. It would have been more prudent on my part merely to have agreed with the authorities, and stated that although the two statements *appeared* to contradict each other yet they were both correct.

Previous to undertaking any independent investigation of my own, I again carefully studied the works of Euler, Legrange, La Place, Herschel and others who had written on this subject. In each of these I found the same error or oversight. All these distinguished astronomers had given theories to account for some movement of the earth, but had omitted to state what the actual movement really was.

It is a well-known fact in astronomy that the pole of the heavens moves about one degree in one hundred and eighty years, caused by a change in the direction of the earth's axis. It is also well known that at the present time the pole of the heavens and the pole of the ecliptic decrease their distance about 47.6″ per century, causing a decrease in the extent of the Arctic circles and tropics to a like amount. It followed, therefore, that the statement that the pole of the heavens traced a circle round the pole of the ecliptic as a centre, keeping constantly 23° 28′ from it, must be rejected as incorrect.

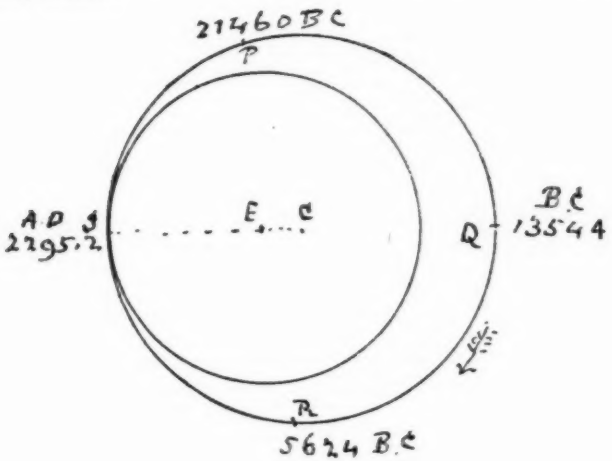
XUM

It might be possible that the pole of the heavens always *moved* round the pole of the ecliptic as a centre, but as these two poles decreased their distance 47.6″ per century, then the course of the pole was not a true circle. Also, it might be possible that the course of the pole was a true circle, but that the centre of this circle was not coincident with the pole of the ecliptic. These were the two problems for investigation, and fortunately my early mathematical and geometrical instruction rendered these two investigations quite within my powers.

The labor and calculations were, however, enormous; and it occupied me more than six years before I could confidently prove what was the true course traced by the pole of the heavens.

This course proved to be a circle, the centre of which was not the pole of the ecliptic, but was a point about, if not precisely, 6° from the pole of the ecliptic. Hence the circle described by the pole was larger than had been imagined, and occupied to be completed about 31,697 years, and not 25,868 as had been stated.

In the following diagram the smaller circle represents that supposed to be traced by the pole, the larger that which is really traced:



E, the pole of the ecliptic, was the supposed centre of the small circle, whereas *C*, 6° from *E*, is the true centre of the circle really traced by the pole.

I found that the centre (*C*) is so situated in the heavens that at the date about 2295 A. D., the pole of the heavens, the pole of the ecliptic (*E*) and the centre of the circle traced by the pole (*C*) would be in the same straight line, or, speaking astronomically, the pole of the heavens. The pole of the ecliptic (*E*) and the centre (*C*) would be situated on the same great circle of the sphere.

The radius of the true circle described by the pole is about, if not precisely, 29° 25′ 47″ and as *C E* is 6°, it follows that the pole in moving from *Q* to *I* varied its distance from *E* 12°.

Having ascertained the above facts, the next step was to find what was the practical value of knowing these items.

First.—The contradictory statement so long repeated in books on astronomy, *viz.:* That the pole of the heavens traced a circle round the pole of the ecliptic *as a centre*, keeping constantly at the same distance of 23° 28′ from it, and yet at the same time decreasing this distance about 48″ per century, must be expunged.

Secondly.—Knowing the true curve traced by the pole, a simple formula could be framed by which the obliquity of the ecliptic and the extent of the Arctic circle could be, and were, calculated for hundreds and thousands of years, and these calculations agreed with accorded observations.

Thirdly.—A simple formula could be framed by which the polar distance and right ascension of every star that had no independent motion of its own could be calculated to the tenth of a second from a single observation, and without reference to the annual variation now found by continued observation only.

Such calculations as the above were previously unknown in astronomy. At this point of my progress I took into my confidence two friends who were able mathematicians and good astronomers, so far as orthodox astronomy was concerned. I asked them to make similar calculations to those

which I had made; they did so, and with the same accurate results, which to them were considered astonishing. This fact convinced me that I was on the right track, because I could, by calculation, arrive at results for long periods, which results had hitherto been obtained only for short periods by perpetual observation.

On examining the true curve traced by the pole, it became evident that at the date 13,544 B. C. (*see diagram*) the pole of the heavens was distant from the pole of the ecliptic *E* nearly 12° more than at present; hence the Arctic circles at that date extended nearly 12° more than they do at present, and consequently reached to nearly 54° of latitude. The true curve traced by the pole showed that at about 22,000 B. C. the Arctic circles began to extend rapidly until they reached a maximum at 13,544 B. C., and at about 4000 B. C., they rapidly contracted. These facts will be clearly understood by examining the large circle in the diagram, and noting how the distance of this circle varies from the point *E*.

Here was a crucial test of the accuracy, or otherwise, of the circle traced by the pole. If I had from calculations correctly ascertained the circle, then a very great change of climate must have come on about 22,000 B. C., reached its height about 13,544 B. C., and almost ceased about 4000 B. C., and this change of climate would have greatly affected middle latitudes on earth. Thus, this remarkable period would have lasted about 18,000 years, and terminated about 6000 years ago.

I now received my first rebuff. Having written to several distinguished geologists, and read a paper before the Geological Society in London, I was informed that my "theory," as it was termed, was quite valueless, because the Glacial Epoch, as it was then termed, had terminated at least 150,000 years ago, and had certainly lasted a million years at least. I, therefore, became a mere laughing stock of the orthodox geologist at the date 1873. One distinguished geologist, however, the late Professor Belt, F.G.S., thought differently, and in an article in the *Quarterly Journal of*

Science, No. xliv, 1874, stated that he claimed that it showed the signs of truthfulness. The result of this paper of Mr. Belt's was that he, too, was laughed at by the then orthodox geologist. During many years these same opinions were held by geologists, and I found it useless to produce my evidence. Then came a book by Professor Prestwich, F.R.S., in which it is stated that the period of 150,000 years claimed by some geologists as the date which has elapsed since the termination of the Glacial Period must be reduced to from 8000 to 10,000 years or less, whilst the duration of this cold period may not have lasted longer than from 15,000 to 25,000 years. (*Geology: Chemical, Physical, and Stratigraphical.*) To me this announcement was like a streak of light coming out of darkness; during fifteen years I had been ridiculed for stating that astronomy proved the same fact, yet now the most experienced geologist in England corroborated that which I had stated.

In the transactions of the Victoria Institute, London, 1892, page 30, is an extract from a paper by Professor Upham, in which he states that from the careful observations of Mr. C. K. Gilbert, Dr. E. Andrews, Prof. Wright, Prof. B. K. Emerson and others in America, the Glacial Epoch terminated not longer than from 7,000 to 10,000 years ago or less. This was the geological evidence for which I had been anxiously waiting during twenty years. So peculiar, however, is the human mind, that within the last two or three years I have received letters from more than one distinguished gentleman, informing me that during more than thirty years they have been quite aware that the Glacial Period lasted not longer than 20,000 years, and terminated not longer than about 7,000 years ago.

The reception by orthodox astronomers of my statements and proofs was even more adverse than was that adopted by geologists. This was only natural. Astronomers referred to their text-books, and finding that what I put forward was in opposition to these books, it was assumed that I was wrong. It was, however, omitted to be noticed that I could, by calcu-

lations, arrive at results which had never before been considered possible.

A somewhat hasty conclusion was arrived at by these gentlemen, and they have not considered it worth their while to more fully examine the facts; had they done so I feel certain they would have altered their opinions. This, however, is a matter of ancient history; the proofs are now too strong to be ignored, and those who continue to ignore them may before long find themselves ignored as competent judges.

Here, then, is the main difference between the hitherto orthodox supposed course traced by the earth's axis on the sphere of the heavens and that which I could prove it really traced. But this difference by no means contains all the various details of the two movements. The so-termed conical movement of the earth's axis was supposed to be due to a vague wabble of the earth. I found that a slow second rotation of the earth took place, which *caused* the two half axes of the earth to describe cones, and the various changes in the right ascension of stars could be accurately explained only by aid of this second rotation. I found that in consequence of the enormous motion attributed to the pole (*i. e.*, that of a circle round the pole of the ecliptic *as a centre*) a corresponding error had been made in the precessional movement of the equinoxes, and therefore in the standard of time. This error, the reason of which is unaccounted for by orthodox astronomy, was exemplified some sixty years ago by the addition of more than three minutes of imaginary time, as is mentioned in a note at the end of Herschel's "Astronomy." The amount of the annual error at the present time, the cause of the error, and the means by which it is to be corrected, have been known to me and to two scientific friends during many years. Many other details of the supposed and the real movement were found to be different, but these are of too technical a character to be dealt with in a popular article.

During the many years that I carried out these investigations, I occasionally found geometricians who were willing

and quite competent to test the accuracy of every portion of my work. Those who did test, assured me that they had proved every portion to be perfectly accurate; unfortunately, however, they showed timidity, and frankly acknowledged that they did not wish to oppose the views of the admitted authorities.

At length I found two investigators, who, with great scientific knowledge, and with those reasoning powers absolutely necessary for investigating a novelty, also occupied independent positions. These were not mere followers of orthodox authorities, and did not accept as infallible any statement which they had not tested in every possible way.

The first of these to whom I will refer is the late Major-General Sir John Cowell. On reading one of my books on this subject, he wrote to me saying that he saw in my books several things opposed to that which he had been taught in astronomy, but that my facts and calculations staggered him. This led to a correspondence which lasted more than a year, during which he put forward every objection that he could himself suggest or that he could obtain from others. It was useless for any person to tell Sir John that I must be wrong because Professor X or Y did not agree with me. He would at once demand the proof of my error, and on nearly every occasion he informed me that the so-called "proof" proved to be a mere opinion devoid of sound evidence, or the quotation from some text book, which he had long seen was itself incorrect. He proved himself to be a clear and unprejudiced investigator, with the moral courage to boldly state that which he knew to be true. In the *Nineteenth Century* for May, 1891, he wrote his first article on this subject, giving various details by which he showed he had thoroughly grasped the problem. Subsequently, he wrote two articles for the *American Journal of Science;* also two articles in the *Yorkshire Weekly Post;* and the night before his sudden death he completed the article which appeared in the January number of the NEW SCIENCE REVIEW. Sir John Cowell's work in helping to make known this recent discovery in

astronomy must render his name one to be honored in the future history of scientific progress.

The other independent worker is one whose knowledge of practical astronomy and accuracy in astronomical calculations are too well known to require any remarks from me; I refer to Admiral de Horsey. Commencing his investigations in a somewhat critical spirit, he soon found that whilst the orthodox belief of the third movement of the earth was vague and contradictory, the second rotation, as I had defined it, was definite and could be clearly proved. Not content, however, with merely testing the accuracy of the data I had given, Admiral de Horsey adopted an entirely original and severe test. He ignored all my items, and set to work to investigate these by a method of his own. Here are his own words relative to his results:

I have tested Drayson's system conversely, *i. e.*, totally ignoring his data and working only from observed positions of stars as recorded in the Nautical Almanacs—data which no one can dispute—I calculated by my own independent method the radius of the circle described by the pole of the earth, the annual motion of the pole, the angular distance between the poles of second rotation and ecliptic, and other fundamental items, bringing my results out to agree with Drayson's data with sufficient accuracy to confirm their truth. This I did by six different calculations, *viz.:* With Polaris, Beta Orionis, two of Alpha Draconis, and two of Alpha Virginis. These tests are to my mind conclusive, because their results could not all coincide with Drayson's data if the latter were not correct.

The statement in the foregoing article that the period of one complete cycle of precessional movement is about 31,697 years, and the consequent apparent periodicity of the glacial epoch, is, I understand, qualified by General Drayson to the following extent, *viz.:* It is the periodicity corresponding to the *present* motion of the pole, and such it has been for centuries. But if any convulsion of nature, either in the past or in the future, should alter the position of the earth's centre of gravity, the gyratory motion of the pole, and therefore the periodicity and intensity of the Ice Age, would be different.

January, 1895. A. DE H.

The crucial test to which I have referred, relative to the date and duration, and also to the date of the termination, of the Ice Age, has recently been found in accordance with the astronomical evidence I gave twenty-three years ago. Admiral de Horsey has applied an astronomical crucial test with the same results.

To those who may be acquainted with orthodox astronomy I submit the following problem:

The mean declination of the pole star, according to the Nautical Almanac for the 1st of January, 1887, was 88° 42′ 21.73″; its mean right ascension for the same date was 1 hour, 17 minutes, 19.632 seconds.

From this data calculate the mean declination and mean right ascension of this star for the 1st of January, 1820, 1770, 1895 and 1920.

I can state that no astronomer or mathematician in Europe or America could make these calculations if his knowledge were limited to the present orthodox belief as regards the third movement of the earth. I know that Admiral de Horsey can make the calculation, and his results agree to one second with recorded observations.

Such facts need no further remarks. Here then is an astronomical discovery which was announced twenty-three years ago. It enables the most exact calculations in astronomy to be made, calculations hitherto deemed impossible. It gave twenty-three years ago the date and duration of the Ice Age, a date only recently found by geologists to be correct. When this date was given, every geologist believed that it was utterly wrong, yet it has been proved to be correct. That which I have put forward and claim to prove is not, as some writers have stated, "a vague theory, intended to account for the Ice Age," but it is an accurate geometrical proof of a movement of the earth hitherto not quite correctly interpreted. To have invented a theory twenty-three years ago to account for an Ice Age having terminated 7,000 years ago, when the geological world were agreed that 150,000 years had elapsed since it terminated, would have been an act of folly of which I was not likely to be guilty. I have no theories, I merely base my conclusions on the accuracy of geometrical calculations.

XUM

THE CLASSIFICATION OF SCIENTIFIC KNOWLEDGE.

By J. Taylor Kay.

It is wonderful that the classification of exact knowledge, as a whole, has not been more largely insisted upon. For many of us believe that in the interests of the national life an intermediary department of knowledge, between the experimental and the applied stages, has become very necessary,—a department of classification for the arrangement and codification of the results of research.

In our daily experience we find that the phenomena of nature may be observed differently from different points of view, may be read differently, and may be recorded differently. The applications of science, too, daily grow, rendering it more necessary that the results of research should be compared, classified, and arranged on a scientific basis. It is only by the regulation, distribution, and organization of scientific truth in its component parts, divisions or sections, its orders, families, species or systems, with their elements, attributes, origins, qualities, uses, etc., and their exact definitions, that this can be done.

In this connection it should be clearly understood that the term science throughout this essay comprehends and includes the laws of natural phenomena whether they relate to mind or to matter.

There is a general idea abroad that science can only relate to the physical constitution of matter; that methods of physical research only are scientific; that certain mental influences cannot be treated scientifically,—memory, judgment, reason, instinct, ideas, the impulses of human nature. This is of course an assumption fairly made, but made only on imperfect conception. The study of physiological psychology has grown to a great extent of late. The reciprocal influence of the mind and the senses is better understood than it was twenty years ago. A somewhat different phil-

osophy to that of Aristotle or Plato or Bacon is being accumulated, and may be brought within the domain of physical science. Bacon himself had a somewhat prophetic guess that there "would be an unlocking of the gates of sense and the kindling of a greater natural light."

The true method of knowledge is experiment; and it is experience, or repeated experiment, that has taught us what *is* the true method of knowledge. Many things are alike in outward form but vary in their constituent elements, and a knowledge of these elements is what we term exact science; our reasoning power enabling us to compare and judge from the known and perceived to the unknown or unperceived.

We find that all the phenomena of nature—whether of matter, energy, life or mind—fall into classifications of natural order and degree according to their characteristics. The movements of phenomena are also divided. Matter has its properties and processes of change; energy its regular action and laws; life its functions and motions; and mind its conscious methods. Time is divided into regular portions; the tides flow and ebb; the celestial bodies have their spheres and periods; all phenomena their specific system, order, and progression. Experience and tradition have shown us also that the instinct of men from the earliest times has noted the distribution of the terrestial world into lands and seas, with their forces and their developments, their special and their peculiar qualities, their classes and orders, genera, families, etc.

There is system, order, and direction in nature. Were it not so chaos would rule again. As the seasons, as darkness and light, time and tide, succeed each other, so order rules throughout creation; and so also should the divisions of natural phenomena, everything apparent to or apprehended by the senses, be studied systematically, in the abstract and in the concrete, each science being investigated on its own particular lines and correlated, precisely as any man may divide his library or his collection of books into departments or classes of subjects, choosing for special study a subject or a class of subjects which suits him, so that he may conquer

it and succeed. The specialist, however, runs a risk of losing sight of the whole in restricting his view to the particular science he is engaged in; his view may be colored or darkened by the narrowing influence of his specialism, except he also study the philosophy of science as a whole. By the study of the classification of the sciences, the particular sciences are analyzed and colligated by the combination and the resolution of our experience of simple elements to the determinations of principles; *i. e.*, from the individual to the universal. The philosopher is thus enabled to investigate nature in all its connections, and render the greatest possible service to the various sciences by re-illumining the whole.

The end of science is the rational interpretation of the facts of existence as disclosed to us by our faculties and senses. The doctrine of evolution has affected the foundations of the old philosophy, and has proved the universality of natural law and order throughout the universe; affecting every department of science or of human thought. It is wonderful to what an extent we have accepted the dogmas of the past; abstract dogmas without scientific foundation; accepted traditionally from the *dicta* of the ancient philosophers. It is never too late, however, to give up our prejudices, and we may yet arrive at the rational conclusion that experimental inquiry is the ground-work of all knowledge. We know and do many things that the philosophers thought impossible of achievement, and we may yet achieve a scientific classification of knowledge.

"Rich soil requires to be often weeded," as my Lord Saint Albans said. The rich soil of modern literature at this moment requires much weeding. It requires much sorting and the better sort classifying. There never was a time in the history of knowledge when we were so overburdened with the productions of the pen. There never was a time when it was so necessary to critically analyse, classify, winnow and review the work of the past.

Systems of classification have been suggested from early times, usually artificial, arbitrary, or fanciful; not scientific;

not according to our knowledge of the laws of evolution in the Cosmos. Mostly dialectical after the manner of Plato and Aristotle, anticipating nature; though Plato affirmed in the *Parmenides* "that all things do by scale ascend to unity." Theoretical systems relating more to the disciplinary education of man, his faculties, than to the understanding of nature; such as the old academic systems of our universities, the *trivium* (grammar, logic and rhetoric), or the *quadrivium* (arithmetic, geometry, music and astronomy). Indeed, it is difficult to offer satisfactory reasons for the disproportionate attention still given to the teaching of grammar in our educational institutions, and why the colligation and classification of the different branches of human knowledge, of nature, should have been so much neglected. It is not always remembered that the mind of man is not the measure of all things, and that the sciences or "the laws of phenomena" can only be understood by the experimental method, by delivering ourselves from slavery to the names of men and to tradition, and returning once more, as little children, to the school of nature.

Soon after the revival of learning the philosophers, Gesner (1548), Trefler (1650), Christofle de Savigny (1587), attempted minor schemes of the classification of knowledge. They were followed by Francis Bacon who, in the *Instauratio Magna* (1605), classified the main heads of all knowledge into history, philosophy, poetry, with numerous subdivisions. To quote the whole of Bacon's *Partitio Universalis Doctrinæ Humanæ* is scarcely necessary here. It was a scientific genesis, but the extent of the loss to humanity by the incompleteness of the structure, and its neglect since, can hardly be conceived. This neglect gave a new lease (probably of two centuries) to speculative philosophy, much to the injury of scientific knowledge. Nothing can be truer than the inductive method of Bacon. As he says in the opening sentence of the *Novum Organon*, "Man, the servant and interpreter of nature, can only understand and act in proportion as he observes or contemplates the order of nature, more he can neither know nor do."

XUM

Bacon's scheme was amplified by D'Alembert in 1761. Both strongly urged an historical (rather than encyclopedic) basis for the study of the sciences. As D'Alembert says: "To trace the causes to which the sciences owe their birth, and to mark the characteristics by which they are distinguished from each other. In order to ascertain the latter it is necessary to comprehend in one general *scheme* all the various departments of study; to arrange them into proper classes; and to point out their mutual relations and dependencies."

This, of course, can be done only by the inductive method: by analysis, description and classification; proceeding from particulars to generals, ultimately distributing all phenomena, or our knowledge of it, into certain great classes of subjects. For phenomena are grouped on intelligible principles: the physical sciences have their relations to the laws and properties of matter and energy; the biological sciences to the laws of life; and the psychical sciences to the phenomena of mind. Each of these great classes has certain broad divisions, the divisions have sections, the sections have subsections, and so on to the minutest detail. The principles, the methods and the practice of each are also subdivided, and the derivations and natural relations of one to the other naturally exhibited.

Descartes (1630) in *De Methodo*, or the "Method of Science," attempted to remedy the defects of the ancient plan of philosophizing, by a method the reverse of Bacon's. Instead of proceeding upward from effects to causes, he proceeded from causes to effects. He reveled in hypotheses. Other attempts followed: as John Rhodius, Padua (1631), Claudius Clement, Madrid (1635), Gabriel Naude, Paris (1643), Garnier, Paris (1678), Bouilland, Paris (1679), John Locke (1689), Leibnitz, Hanover (1700), Fontanini, Rome (1709), Marchaud, Paris (1709), Conyers, Middleton (1723), Abbe Girard, Paris (1740), Chambers (1738), De Bure, Paris (1760), Ersch, Jena (1793), Denis, Vienna (1795), Warin, Paris (1798), Ameilhou, Paris (1799), Daunou, Paris (1800), Butenschoen, Colmar (1800), Parent, Paris (1801), Brunet, Paris

(1809), Jeremy Bentham (1816), Coleridge (1826), Ampére, Paris (1834), Preusker, Grossenhain (1830), Hartwell Horne (1830), Whewell (1840), Lord Lindsay (1845), M. Albert, Paris (1847), Merlin, Paris (1847), Thieneman, Berlin (1847), Schliermacher, Berlin (1847); and a very important essay or "Remarks on the Classification of the Different Branches of Human Knowledge, with a System Proposed by the Author," by John W. Lubbock, Treasurer of the Royal Society, was published in 1839. Later attempts at classification were made by Hegel in his "Logical System" (1817), but not discussed in this country until late years; and Comte (1842), who distributed all knowledge into "Abstract and Concrete;" the abstract sciences treating of the elementary laws or general facts on which all particular facts depend; the concrete sciences being the knowledge of objects as actual combinations of these elements; the one investigating existence, the other individualizing it.

Comte's main classifications run thus: [The order is determined by the degree of simplicity of their phenomena, *i. e.*, a serial arrangement of natural order of dependence on each other, beginning with the most general (mathematics) and ending with the most complex (sociology).]

1. Mathematics. 3. Physics. 5. Biology.
2. Astronomy. 4. Chemistry. 6. Sociology.

(This last including History, Law, Commerce and Society generally.)

Herbert Spencer's classifications are founded very much on the lines of those of M. Comte. A very valuable attempt was made by H. M. Stanley, in *Mind*, Vol. IX (1884) p. 265, who, placing mathematics as the foundation of all science, tabulates the classes of Natural Phenomena thus:

Mathematics:
- Science of Atom ..... Chemistry.
- Science of Molecule ..... Molecular Physics.
- Science of Mass ..... Molar Physics.
- Science of Aggregate Cell-Masses ..... Biology.
- Science of Individual Man ..... Psychology.
- Science of Human Aggregates ..... Sociology.
- Science of God ..... Theology.

The order of aggregation plainly is, atoms into molecules; molecules into masses; cell-masses into plants, animals and man, and these into societies. Nature is thus a combination of wheels within wheels. This classification presents the general order of the *dependence* of the sciences.

Dr. Dewey, of the State Library, New York, has introduced an arbitrary system of the decimal classification of all literature. He takes three figures; hundreds representing CLASSES of knowledge, tens representing DIVISIONS of the classes, and units SECTIONS of the various divisions: the noughts being used as a section for the encyclopedias, periodicals, histories and general esssays and theories in each class of subjects. This has been found to be of very material use in museums and libraries, because it is very conveniently adapted to museum classification and library shelving arrangement, as by the addition of a decimal point, and additional numbers afterward, the books on the shelves or the objects in the cases are particularly indicated in the system.

It is to the classification of phenomena as they present themselves in the cosmos that we must look for improvement and guidance in our knowledge of natural law,—the law that governs all phenomena,—the cosmos of order, harmony, truth, combined within the universe. The success of the greatest scientists has been by investigating and proving portions of this great law and their developments. The word "law" itself indicates a rule of order or system, fixed, true; in nature the uniform methods or relations according to which material and mental forces act in producing effects or are manifested in phenomena. And this law is supreme; must be treated reverently; with faith in the highest as the chief corner-stone; faith in His spirit from which all nature moves and has its being.

And so surely as the truth that "one plus one makes two" contains the universal applicability of causation, so surely must we arrive at the conclusion that the world is a cosmos, a harmony. There is no chaos in nature's rule. A chaos in the sense of an absolute non-existence of law is an impossibility. The chaos is in our own ignorance.

The patient interrogation of natural phenomena, whether of mind or of matter, for the pure love of knowledge, should be more largely inculcated. This can be done by the encouragement of the study of their classification and their relationships, their underlying principles and meaning. Indeed, the fundamental principles of science cannot be properly understood except by the study of the connection, the origins, the laws, the processes, and the objects of phenomena, as well as their relationship to the law of causality or continuity in change; because our sectional ideas of things are continually in process of correction.

Their relationships: for we find that divide as we may the sciences affect each other directly and indirectly. The same relationships are found amongst different sets of phenomena, and many discoveries have been made simply by the analogy of one set of phenomena with another. So the details of science are assisted by the continuous helping of each division of the classes by the others, and the principles of the laws of nature are thereby more generally investigated. Indeed, the classification and the terms used (when strictly scientific) act and react on our knowledge and have great value in the further discovery of scientific truths.

Every system has its correlated parts; and we cannot have a proper knowledge of the whole without a perfect study of the parts and their changes,—the actions and reactions which produce equilibrium and stability. Nature as a whole is a system of correlated parts. Every department and sub-department of nature to the uttermost details are systems of correlated parts. Everybody; every atom.

By this interesting study many natural laws, with which we are as yet unacquainted, are more freely open to elucidation—natural laws bordering on what we call the spiritual world; the world of instinct and sympathetic vibrations in men and animals, or of the tremors and oscillations of ether through space; "the silent depths to us unknown;" subjects that require more investigation than they have yet received, and which deserve to be carefully studied by

observation and experiment and the classification and comparison of the results.

Theoretical difficulties may readily be raised with regard to some of the details in the classification of the phenomena of nature, but in practice they disappear. The practice of our institutes of learning may explain one of these. Though we cannot theoretically draw a line between biology and geology, yet in practice the relations of the two become thoroughly known and are properly adapted to the various branches of study. The study of the relationships of the various groups of science is beneficial to a great degree; in their interpretations, their dependence on each other in order and time, and the regularity of the series in their complex connections with never a break. Yet each phenomena, material or mental, naturally falls into the class which has, apparently, certain characteristics in common with it; naturally separating from the rest. Great groups of sciences, with their respective sub-groups, containing truths of general application and truths of specific application, form together, suggesting that higher law which ultimately connects all in one stupendous whole.

The comparative neglect of the systematic arrangement of the results of science has a most vicious influence on the progress of knowledge generally. It is provocative of inaccuracy and confusion, and encourages the growth of a pseudo-science quite common in literature. It counteracts true progress; for it is only by the systematic arrangement of the results that the student knows what has been before attempted or achieved, and avoids difficulties that have been surmounted or questions that have been already decided. The better organization of the results of science by classification would facilitate the work of every original investigator. Its neglect has had a far-reaching influence; for, as a consequence, there is a great tendency in the direction of further disorganization by the interchangeable use of terms not always synonymous, reflexive or reciprocal in their meanings. Denotation and definition are closely connected with connotation and classification. As a rule, scientific words

have an exact etymology of their own, with attributes; special meanings which cannot be used synonymously or interchangeably. But the indiscriminate use of terms very nearly allied to express the same thing has grown to a great extent.

The connection between things and the names of things is much closer and has a greater influence on our knowledge than at first sight appears. It is by their names that we know them; that we appreciate and understand the connection of one thing with another and of one idea with another. Names are the language of learning. They indicate our conscious perceptions, through our intellect, our understanding of seeing, hearing, tasting, smelling, feeling—our senses. We indicate a thing by a name to distinguish it, to connote it; and though many things shade out into other things, our knowledge of them consists in our perceptions of their special qualities and their connections and relations. Nothing is absolute *per se*.

It may be taken for granted that the books on a library shelves, or the objects in a museum, are not arranged in an alphabetical order, but in classes or groups of objects relating to each other—because an alphabet is not logical or reasonable, being an empirical system of signs—that things of a similar nature are placed together; that, though botany is separated from zoölogy, and both from geology, they are still in natural history; that, though mathematics, astronomy, physics, and chemistry be separated, they are still connected in the department of natural science. The underlying relationship is in some degree considered. Only in a slight degree, for the possibilities in the future study of the relationships of natural phenomena have not been yet properly appreciated. It may, however, be noted that the study of systems of methodology is growing both on the Continent and in the United States of America.

The new catalogue of the British Museum is of great national value, because it has partly unlocked sources of knowledge which were to a great extent hidden. It is an author-index to a vast mass of literature, and occasionally

saves the reinvestigation of work already done. That is, if the searcher knows the names of every person who has ever written on his subject. But let us consider for a moment of what inestimable value it would be if the books were classified under subject-headings; if the labyrinth were made straight, and the library and its catalogue made into so many departmental sections with classified catalogues of the subjects! As a librarian, I have had a large experience of the waste of valuable time by scientific men in searching out references through author-lists—time which might have been saved by means of subject-lists and classification.

It would be to the best interests of the nation that there should be a government endowment of investigation and classification. The benefits would be national as well as universal. We cannot overlook the fact that there is required a higher power of mental action in research than in applying the knowledge obtained. We cannot afford to neglect our scientific men, our lovers of knowledge for its own sake. The inventors, patentees, and adapters of the discoveries of others have grown enormously; but the discoverers, the researchers, are few and far between. A discoverer creates new knowledge; an inventor only applies it. It is essentially necessary that this distinction should be quite clear. There is a wide line of demarcation between them. The latter rightly has his reward, but the former, in the pursuit of difficult researches, from at least a spirit of inquiry, cannot render less complete his noble occupation for commercial purposes. Science and her devotees are jealous lovers, and bear no break in their connection. The scientific investigator must sacrifice his whole time and attention. Research will brook no odd hours spared from official duties.

Discovery is national work, and discoveries are national property. Every advance in scientific research has been of benefit to the people, and directly and indirectly to the government. Increased revenues have resulted from increased progress in the applications of science. Probably war has been prevented by the improvements in cannon, gun-cotton,

projectiles, armor-plated ships, telegraphs. And probably many preventable accidents would have been avoided—much disease and death by cholera, contagious diseases, colliery accidents, pollution of air and water, and other evils which depend on physical and chemical conditions—if government had encouraged learning and research to a greater extent.

It cannot be denied that research in this country has been to a great extent neglected, and has been one of the causes of our manufactures and commerce passing into the hands of foreign nations. It has become very necessary that government should encourage systematic scientific research to a greater extent than hitherto, because it is of immense value to the nation and especially to the government. It is indispensable to national progress, for the results of research, discovery and invention ultimately benefit the country.

It should be remembered, also, that government already makes experiments, investigations and explorations at great cost which cannot be expected of private individuals or of societies, including investigation such as magnetic, meteorological and astronomical observations, determinations of longitude, researches on tides, density of the crust of the earth, experiments on guns and armor-plates, the best form of ships, trigonometrical surveys, deep sea dredging operations, geographical explorations, Arctic expeditions, and many others.

In the eighth report of the Royal Commission on Scientific Instruction and the Advancement of Science (1875) occurs the following:

"EVIDENCE AS TO THE INSUFFICIENCY OF THE PRESENT ORGANIZATION.

"The evidence we have taken as to the sufficiency or insufficiency of the work done for the advancement of science, including that of the government departments, is very copious. A large portion of it is contained in the volumes already published, and it will have been seen that there is a general concurrence of opinion, that, even in the interests

of the departments themselves, more ought to be done by the government in the way of investigation, particularly in respect of those sciences the practical application of which has been developed, or the scope of which has been enlarged, by discovery within recent years. These opinions are entertained alike by persons engaged in scientific work under the various departments of the government and by scientific men having no connection with the State."

The necessity that was then shown has, allowedly, become very much greater in the last twenty years.

What legislator would oppose a subsidy to investigation in the best interests of the nation? There could be no greater benefit to the country than a government endowment of research and its systematic record in science, theoretical and applied, in literature and art. This century has been essentially a critical century; the old work has been critically reviewed; the science, art, and literature of the past have been winnowed; the best part of it re-edited; and a systematic endowment to facilitate its application to the purposes of the people would be an unmitigated blessing.

The importance of a more general cultivation of the scientific spirit at the present time cannot be over estimated. Dilettanteism and the study of useless subjects have grown to a great extent. Literature is more and more treated as a relaxation from the cares and worries of life; whilst the study of the foundations of knowledge does not proportionally increase. Indeed, scientific knowledge is treated as if it were distinct from ordinary knowledge, yet all knowledge should be systematic and scientific. The relation of science to every economic aspect of life has been overlooked or neglected. The literary side of the scientific spirit must be more encouraged; and a more practical sympathy would be enlisted amongst the people generally in the revelations daily made in the wondrous tale of creation.

In the light of larger and more illuminating views of the various sections of human knowledge, portions hitherto only partially explored will acquire greater interest and be more keenly cultivated. An impetus will be given to more

persistent researches into the secrets of nature, and into the laws of the distribution in space and time of matter, of energy, of life, and of mind. The old metaphysics will be superseded by experimental science. Psychology will be treated experimentally.

Bacon's "Science of nature with fixed eternal universal principles" is possible; and knowledge may be placed on a firm foundation and cemented into a harmonious structure in its more systematic arrangement by classification. The benefit likely to accrue to humanity by the furtherance of its study, and by the more systematic encouragement by government, has been pointed out. To the general view the various classes of knowledge may occasionally appear to overlap each other, but this is for want of scientific discrimination. There is no limit to the advance of knowledge, but it must be systematic. There is no limit to the benefit nature is able to confer upon mankind; and we do not doubt but that a scientific study of nature may be achieved which will accurately discriminate the discrete degrees in all the phases of the cosmos, and will educate the minds and deepen and enrich the power of all men.

XUM

CLIMATE AND HIGH ALTITUDES.

By Henry Russell Wray.

The Easterner, bred and born at sea level, has a very vague idea of that part of his country which is at a cloud height, and he has scarcely any conception of the governing climate of such a section. The purely picturesque appeals to the tourist, and he gives hardly a thought, surely not a serious one, to the high altitude section through which he passes.

The Adirondacks have accomplished wonderful temporary healings and permanent cures for certain pulmonary troubles, yet their beneficial results do not compare in extent with those of that section which lies at an altitude varying from three thousand five hundred to eight thousand feet above the sea, known as the High and Dry Rocky Mountain Belt, whose heart is Colorado.

From a statistical comparative weather bureau report little idea could be formed of this climate, for in these comparative statements the dry and rarified condition of the air is not fully appreciated. The dominant feature of this high altitude is its light, dry and electrical atmosphere, with its abundant sunshine and clear weather. This is true of all seasons at the six thousand foot level, for while rain falls in torrents for an hour nearly every day during May, June, July and August, the sun always shines the rest of the day, and ten minutes after the rain has ceased the sandy roads are dry and the air does not retain the moisture. After these months, not a drop of water falls from the cloudless sky, and snow storms are few and light.

The mercury occasionally drops to 20° below zero during winter nights and rises to 60° in the shade the following morning, while in summer, although a blanket is always a nightly necessity, the thermometer often registers 90° during the day, and the heat of the sun is always intense. These extremes are much less keenly felt than they would be at sea level, owing to the dryness of the air.

It is a region of out-of-door life,where regaining of health is a business. Thousands of beings, whose existence would be measured by weeks if they returned to the dampness of sea level, here are well and active. It is true that some cases of pulmonary trouble are not benefited at the six thousand foot elevation, but either the disease has advanced so far that the invalid could not live more than a few weeks in any climate, or he is affected with some heart trouble. Cases of the latter sort migrate to an extention of this dry belt,which descends into New Mexico, along the Pecos and Rio Grande valleys, where the elevation is from three to four thousand feet. There the action of the heart is modified and the patient is more benefited than in the higher portions of the Rockies.

Treatment of phthisis pulmonalis has materially changed in the past two decades. The Riviera, Italy, Egypt, Algiers and Madeira still receive their quota of invalids, but to the high altitudes go the majority. A quarter of a century ago, to have suggested sending these patients to such a place as the Dry Plateau of the Rockies, where the difference between the temperature in the sun and that of the night is often as great as 70°, would have been regarded as almost criminal, certainly unscientific. But science has made wonderful progress, and phthisis is no longer regarded as fatal.

The Dry Belt of the Rockies, with Colorado Springs as a centre, has often been compared with Davos Platz, Switzerland. The tabulated comparisons of these two famous health resorts are not without interest. They were compiled by an officer of the United States Signal Corps, and seem to point to the fact that our own country furnishes the better haven for those affected with pulmonary trouble, asthma and bronchitis.

The following are the comparisons for five months:

	Average Maximum Temperature.	Average Minimum Temperature.	Average Temperature.	Average Percentage of Humidity.	Number of Hours of Sunshine.	Total Rainfall in Inches and Hundredths.*
NOVEMBER.						
Davos Platz	54	14	34	78	96¾	3.03
Colorado Springs	49	24	33	67	169¼	0.22
DECEMBER.						
Davos Platz	43	3	28	78	.....	0.08
Colorado Springs	49	21	30	57	.....	0.07
JANUARY.						
Davos Platz	39	1	22	81	120¾	0.79
Colorado Springs	39	12	21	59	165¾	0.16
FEBRUARY.						
Davos Platz	44	6	21	82	54¾	4.25
Colorado Springs	42	14	26	61	161	0.60
MARCH.						
Davos Platz	46	2	26	73	127¾	1.01
Colorado Springs	54	28	39	57	214	0.12

* The usual rule in the service is that one inch of snow will equal one-tenth inch when melted (which is the record given here), so by multiplying the record by ten, one can approximate closely the depth of snowfall each month.

The city of Colorado Springs is seventy-five miles south of Denver; its latitude 39°, its longitude 105°. It is about on a line with Philadelphia, though its climate differs widely from that of the Quaker City. It is situated at an elevation of over six thousand feet and is five miles from Pike's Peak. The air is so pure and clear that mountains a hundred and thirty miles distant can readily be seen by the naked eye. Fogs and mists are unknown, and the Easterner is surprised in midwinter to see small patches of snow lying in beds of dust. The snow disappears by evaporation and mud does not exist even in the rainy season.

The sun shines three hundred and thirty days during the year, and the intensity of its heat is due to the clear, dry and rarified condition of the atmosphere. There is scarcely a

day in winter when the most sensitive invalid cannot sit on the porch with the wraps he would wear in the East. The heat of the sun can be readily appreciated when one realizes that between the sun and the shade in this altitude there is a difference of 50°. The moment the sun sets this difference is keenly felt. The shortest day in winter the sun rises at eight o'clock and sets at four.

No climate is perfect, and that of Colorado Springs is not an exception to the rule. During November and March, each week brings with it at least one wind storm, and when it is remembered that no rain has fallen since August, the accompanying dust may be imagined. These storms are not violent enough to cause much damage, but they are exceedingly exasperating to people of a nervous temperament. Such people, however, as a usual thing, are not benefited by a residence in high altitudes. The air is too exciting for them, and they are better at a lower level. Physicians, as a rule, recommend their patients to leave this altitude for a few weeks every year, as their nerves are apt to become too highly strung after a long residence at cloud height. The stimulating effect of the atmosphere is, however, extremely beneficial to most people for eleven months of the year. It increases the appetite, assimilation of the food is facilitated, the number and depth of the respirations are increased, and the chest expands rapidly. Strength soon returns, and with it, reviving spirits.

Davos Platz is an Alpine Valley in southeastern Switzerland, five thousand three hundred feet above sea level. The climate resembles that of Colorado Springs, the sun being as hot, though the temperature in the shade is lower. The unpleasant feature of Davos is the south wind, which brings in its train cloudy skies, morning fogs, and cold gray mists.

The surrounding mountains are covered with snow, which this warm wind melts rapidly, and the air becomes filled with moisture. Snow begins to fall the latter part of October, the depth varying from one inch to two feet, and the ground remains covered with it until April.

Owing to the surrounding mountains, the sun does not

rise until ten o'clock, and sets at three, so that the days there are very much shorter than at Colorado Springs.

While the summers are delightful at the Springs, Davos is only a winter resort, as the melting snows of spring time make the atmosphere too damp for health.

At Colorado Springs there are twenty-eight good days in a month, at Davos only twenty. At the Springs during the shortest day of winter the invalid enjoys eight hours of sunshine, at Davos five.

At Davos the amusements are restricted to sleighing, toboggoning, and skating; at the Springs, riding and driving are possible nearly every day, and golf, polo, lawn tennis, and out-of-door sports generally, most of the year. At Davos life in a hotel is the only one possible, while the Springs is a town of thirteen thousand inhabitants, with habitations of all sizes, hotels, churches, theatres, clubs, schools, and circulating libraries, so that an invalid is able to lead the life that pleases him best, and indulge in his favorite occupations, in this city in the clouds.

Yet while Colorado Springs is the metropolis, and naturally the mecca to which those affected with lung trouble at first journey, its climate is not as perfect nor its altitude as suitable, for many cases, as hundreds of smaller settlements which dot this great high and dry belt—the great region where the exile finds new life and may enjoy it.

THE CURVATURE OF SPACE.

By John Dolman, Jr.

The infinity of space, being necessarily incomprehensible, has always greatly bothered the philosophical; but it was not until recent times that this infinity came to be seriously doubted, or rather its necessity called in question. Now, there is quite a respectable body of the learned who hold that space may be a finite number of cubic miles; that it may have four dimensions; that the sum of the angles of a rectilineal triangle may be slightly more or less than two right angles, and that parallel lines may finally meet.[1]

If in imagination you go upward in one direction, in a perfectly straight line, the ordinary supposition is that such motion may continue indefinitely, and with continual departure from the point of starting; but this is not the only supposition. It has been supposed that you might return from below to the place from which you started. Such is the common way of stating this supposition, but it is misleading, for such journey would not, in fact, be in a perfectly straight line. The line would be straight according to accepted definitions. It would not depart from straightness in any visible or conceivable manner; but, according to the theory hereafter to be explained, it must curve in the direction of a fourth dimension of space in order to return into itself. If this fact is impressed upon the mind, it will prevent much confusion in the study of the subject. The whole theory of hyper-space and non-Euclidean geometry rests upon the supposition that straight lines are not straight. Though they be straight, according to the definition of Leibnitz, or the definition of some one else, they are not straight. No writer of intelligence intends to say that motion in one direction, in an absolutely straight line, will run up against a barrier

[1]See "Bibliography of Hyper-Space and Non-Euclidean Geometry," by George Bruce Halsted, American Journal of Mathematics; vol. 1 pp. 261 and 384; vol. 2 p. 65.

beyond which there is no space; nor that a perfectly straight line, which does not curve at all, in any imaginable or unimaginable direction, will return into itself. Remembering this, let us briefly examine the arguments commonly advanced to prove that Euclid's geometry may not be exactly true, and that space may be a finite number of cubic miles.

According to the usual conception, space has three dimensions, length, breadth and height, and is infinite in each dimension. If you conceive a point to move in any given direction, the successive positions of the point will form a straight line having one dimension only, namely length. If the line moves parallel to itself, or so that every point in it takes an independent path, it will form a plane or surface having the dimensions of length and breadth. Again, if the plane moves parallel to itself, or so that every point in it shall describe a separate path, there will be generated a solid having length, breadth and height or thickness; and here this process ends so far as our mental perceptions go. But, it is asked, why must it really end here? May it not be possible that the solid should move in some other and to us inconceivable direction, so that every point in it shall take a different path, and thus generate a four dimensioned figure? It is inconceivable truly, but is it therefore impossible?

Suppose there was a long and very narrow tube, straight or curved, and in that tube there lived a very narrow worm that just filled the bore of the tube. He might move freely forward and back but never sideways or up and down. Suppose, also, that he and his ancestors from remotest times had been born in that condition. Suppose further, that he could not imagine or conceive of the possibility of any other motion or direction than forward and back. Sideways and up and down are impossibilities to him, unimaginable, unthinkable. This would not be a violent assumption, for, subject to his conditions of existence and ancestry, how could the mind ever have formed the idea of any other direction than the one in which motion was possible? When this worm moved forward, he must think of himself

as getting further away from the point he started from; though if his tube, his space, his universe, were in the form of a circle, we know he might return to the starting point by continually going away from it. This would seem necessarily an impossibility to his mind, for it involves the bending of his space in a second dimension, and his mind holds but one dimension only. A second dimension of space is just as unmeaning for him as a fourth dimension is for us.

Again, let us imagine a race of flatmen, restricted in their perceptive and conceptive functions to two dimensions. Let them live, say, in a plane between two plates of glass, or against a vertical wall, or in a vertical plane without contact with any physical surface. Let them be capable of moving forward and back and up and down, but never sideways. That they may not be mere abstractions, we may suppose that they have a small uniform thickness, of the thickness of their space, but are unaware of this fact and unable to conceive of sideway motion. The circumference of a circle in their plane might represent their "earth." They might walk on or around it, and two of them could pass each other by one going up over the head of the other. If a body passed sideways through their space, they would perceive only that portion which happened at any moment to be in their space, the edge of a section; and that portion would to them seem to be the whole of the object. Say, for illustration, a lead pencil be passed perpendicularly through their plane, they would see the edge of what we would call a circle; they would perhaps call it a sphere, a figure resembling their "earth" in shape. They could go around it and view it fully on what they would suppose to be every possible side; bound it in every possible direction; yet they would not really see the whole of it. If the lead pencil be turned from the perpendicular to the oblique direction, the circle would change into an ellipse; or if, instead of the cylindrical pencil, a cone be passed through, the circle would change in size in a most unaccountable manner. If one of these flatmen acquired the conception of sideways, he could, by moving never so little in that direction, vanish instantly from the sight of his

fellows. Now let us suppose their space to be curved. Instead of a plane let it be in the shape of the surface of an immense sphere. This could make no perceptible difference to the flatmen, for the curvature would take place sideways. Every line that really formed a great circle of the sphere would to them be absolutely straight, and every one of their straight lines would necessarily be a great circle of the sphere and return into itself. Their space, though it remains as before homogeneous and unending, is now a finite number of square miles. Some of the theorems of Euclidean geometry are now no longer true. The angle sum of a rectilineal triangle will always exceed two right angles by an amount depending upon the size of the triangle. Though, if their "space" be very large compared with their "earth," they might never find out this departure from Euclid's theorem, because for relatively small triangles on a sphere the angle sum does not sensibly differ from two right angles.

Let us now carry this analogy one dimension higher. Suppose we are limited in our perceptions and conceptions to three dimensions, while four, in fact, exist. It is inconceivable, of course; that is the limitation of our minds; but is it therefore impossible? Suppose further that our space has a uniform curvature in the direction of a fourth dimension, so that all straight lines, absolutely straight to all our perceptions or conceptions, will return into themselves within a finite distance. Space would then be a finite number of cubic miles. The theory of parallels would be wrong, and the angle sum of a rectilineal triangle would not exactly equal two right angles.

The subject started with Lobatschewsky, who published a synthetic non-Euclidean geometry in 1829, denying Euclid's axiom in relation to parallel lines. It forms a consistent, but false, geometry, in which the angle sum of a rectilineal triangle is always less than two right angles. It has since been found to apply to an imaginary surface called the pseudospherical surface, developed analytically in 1868 by Beltrami. The leading mathematical paper on space curvature, by Bernhard Riemann, was published in 1854, entitled "Upon the

Hypotheses which Lie at the Base of Geometry."[1] Riemann developes by analysis what he calls the general notion of multiply-extended magnitudes, in which space magnitudes are included. He says the properties which distinguish space from other conceivable triply-extended magnitudes are only to be deduced from experience, and we may investigate their probability. A pretty complete account of this view of the matter, the details of which are too technical for this article, may be found in the Encyclopædia Britannica, entitled "Measurement."

Some of the consequences of a fourth dimension of space are curious and perhaps important. It might, for instance, be supposed that an immense solid body existed indefinitely near our space, but in the fourth dimension and therefore unknown to us, through which physical forces might be transmitted. This would do away with the necessity of an ether, and yet not require us to suppose anything so improbable as action at a distance.[2] It might furnish new explanations of chemical reactions and molecular phenomena. A complete mechanical model of the material universe might be conceived, in which each atom of matter would be the section of a long thread extending and moving in the fourth dimension. In fact, all physical changes could be explained by considering each form as the three-dimensioned section of a four-dimensioned body passing through space. Even the different appearances of a man from infancy to old age have been, somewhat fancifully, likened to different sections of the true four-dimensioned, unchanged and unchangeable man.[3] If any one obtained a knowledge of the fourth dimension he might, as the Hindoo adepts claim to do, disappear at will by moving in that direction, and reappear at another place. If space be curved, London and New York may be less than a yard apart, and the adept might pass from one to the other instantly through the fourth dimension. A journey from one

[1] See a translation by Prof. Clifford in "Nature," vol. 8, pp. 14 and 36.
[2] W. W. R. Ball, "Mathematical Recreations and Problems," London, 1892.
[3] C. H. Hinton, "Scientific Romances," London, 1887.

planet to another might be possible. The inside of the best burglar-proof vault made would be open as a public park to one who had this knowledge, or a closed material surface or shell could be turned inside out by simple flexure, without stretching or tearing.[1]

Professor Clifford, in a lecture before the British Association, upon "The Postulates of the Science of Space," was very bold in his declaration of belief in space curvature. He concluded his remarks in the following language:

"The universe as known is again a valid conception, for the extent of space is a finite number of cubic miles. And this comes about in a curious way; if you were to start in any direction whatever, and move in that direction in a perfectly straight line, according to the definition of Leibnitz[2], after traveling a most prodigious distance you would arrive at—this place. Only if you had started upward you would appear from below. Now one of two things would be true, either when you got half-way on your journey you came to a place which is opposite to this, and which you must have gone through, whatever direction you started in, or else all paths you could have taken diverge entirely from each other until they meet again in this place. In the former case every two straight lines in the plane meet in two points, in the latter they meet only in one. Upon this supposition of a positive curvature, the whole of geometry is far more complete and interesting. The principal of duality, instead of half-breaking down over metric relations, applies to all propositions without exception. In fact, I do not mind confessing that I personally have often found relief from the dreary infinitudes of homaloidal space in the consoling hope that after all this may be the true state of things."

The mathematical development of extended magnitudes proves nothing for or against the possibility of hyper-

[1] Prof. Newcomb, in American Journal of Mathematics, vol. i., p. 1.

[2] If a piece of the surface adjoining a line can be slid along it and always fit closely, and if turned over on the other side of the line and slid along it will still continue to fit closely, Leibnitz says the line is a straight line.

space. To call these analytical developments "curved space," or "dimensioned space," and to speak of their lines and surfaces, is pure assumption. The possibility of a fourth dimension may be an interesting speculation from the standpoint of natural or mental philosophy, but the mathematical work done is no evidence of even the reasonableness of the inquiry.

As an extreme case, take the continuous magnitude called time. Time, because it is homogeneous, must be unending, to use an expression of Riemann's; but, say the mathematicians, it is not therefore infinite. Its one dimension may be treated analytically as a line, which, though it seems to be straight, may with perfect (mathematical) consistency, be supposed curved in a second dimension and return into itself, so that if we move in time, in any direction, in a perfectly straight line, according to the definition of Leibnitz, after traveling a most prodigious distance we would arrive at—this time, etc. When one brings the mind from such wanderings back again, as it were, to the axis of reals, and contemplates with proper perspective this analytical, finite, curved time, it does seem as though the genuine time was still going on in its metaphorical straight line. The application of the analytical treatment of magnitude in general to space, time or other reality or mental object, is metaphorical only, and the fact that magnitudes may be treated in a certain way mathematically proves nothing whatever about real or conceptional space.

I fail to see that the so-called "dreary infinitudes" are avoided by assigning a curvature to space. If we think of a curved line we must entertain the notion of a second dimension in the direction of which the curvature may take place. And so with a curved surface, a third dimension must be conceived to account for the curvature. If space be finite it admittedly must be curved, and there must be a fourth dimension to accommodate this curvature, room in which it may be described, and we then would have an infinite four-dimensioned space; or, if that be supposed finite,

we would be obliged to add to the dimensions, *ad infinitum* or until we admit an infinite homaloidal space.

If there be anything in such a theory whatever, the curvature of space amounts, it seems to me, to only this; let a fourth dimension be granted, then our physical universe, including the air and the ether and all we know, may be curved, and may be stuck against a solid, indefinitely near us, but in the fourth dimension and therefore unknown to us, through which physical forces may be transmitted. In drawing our straight lines, in sighting our telescopes, we may be physically compelled to follow this curvature, and if we could travel upward in what seemed to us a perfectly straight line, we might return from below; but in spite of all this, space, tri-dimensional space, would still be homaloidal and infinite, and a mathematical straight line would still be possible which would not return.

Let us return to the flatmen for an analogy. They are stuck against the surface of a sphere of whose existence they are ignorant, and physically compelled to draw their straight lines in it. Their telescopes, if they have them, could sight only along it, and if they could see far enough they would see the backs of their own heads; but the real direction of their straight line at any point is not around the sphere but tangent to it, and the plane of their imagination really extends to infinity. Their departure from it is a physical restriction, just as a man walks in a circle when lost in the woods.

If there be a fourth dimension, it cannot differ in character, but only in direction, from any of the three with which we are familiar. If a great circle be drawn on a sphere, and held edgeways to the eye, it may look like a straight line. The eye, the mind, would be mistaken in calling it a straight line, but the mental conception of a straight line would not therefore be invalidated. A real straight line still is possible, extending indefinitely in the apparent direction of this supposed straight line.

In the first and second volumes of "Mind" there is published an interesting controversy upon this question between

Prof. Helmholtz and Prof. J. P. N. Land. It was started by Helmholtz as very much of a physical inquiry, but under the able analysis of Prof. Land rapidly narrowed into a definite psychological question, namely: Is any kind of space, except the space of Euclid, capable of being imagined?

Space, being the form of our objective world, or, as Karl Pearson puts it, the mode in which we perceive, is intuitive, *a priori* and transcendental. To be space at all it must be imaginable. The axioms of geometry are equivalent to definitions or descriptions of space.

As soon as the mind perceives an object as an existence outside itself, it forms the idea of space in which the object is placed; in this sense space is the mode in which we perceive. Kant says "space in the abstract is nothing but the naked possibility of outward phenomena."

Space is therefore transcendentally received and endowed with certain necessary qualities without which it is impossible for the mind to form the idea of space; and flatness, when rightly understood, is one of them. Not that the mind transcendentally receives the idea of flatness *per se*, but that which the analytical mathematicians have chosen to term flat or homaloidal space, whatever its dimensionality may be, is space pure and simple, and the only conception which the mind is capable of recognizing as space.

This is proved by inquiring if the mind can imagine any other kind of space or not. This is the only test; and Helmholtz, realizing this and accepting the issue, bent all his energies to form an idea of what he called pseudospherical space, by describing the alleged variations in the size, shape and direction of objects and physical straight lines (the only kind, of course, that can be seen at all) in a pseudospherical space when the observer moves. The descriptions are not clear, nor is there any evidence or assertion that they are founded upon mathematical demonstration. They are apparently loose speculations on the part of Helmholtz. And this view is strengthened by the fact that he falls into several obvious errors as to Gauss's measure of curvature, and the reality of a pseudospherical surface. Admitting,

however, that they are perfect and may be fully realized, any apparent eccentric behavior of material objects should not affect our conception of space in the abstract. Such apparitions might be referred to unknown physical laws, to visual aberration, to some peculiar molecular condition of the air, to refraction of light, or, perhaps, distortion of the ether; but that absolutely empty space should affect material objects is inconceivable. No matter what visual objects appeared to us, and no matter how they acted, I fail to see that our notion of abstract space should be thereby modified. If a physical straight line be impossible, or, in other words, if the geodesic be not straight, yet the geometrical straight line is possible. Though we have not access to the place of all its elements, these elements do exist, and in the space of our conception.

Take the manifoldness, by courtesy called space, of uniform positive curvature and finite volume, and assume, and it is a pure assumption, that the mind is capable of forming some sort of image of it; what does it become to the mind? Space? Not at all. It becomes a construction in space. It occupies a region in that purely mental necessity which we call space. According to our only possible conception, space penetrates every corner of the mind, and in the mind is nothing that is not in space. Helmholtz's efforts are like trying to look at space from the outside, but the outside of space is a contradiction of terms, and yet a finite space cannot be thought without an outside. If we conceive of space as curved and finite, then, no matter how we may try to ignore it and turn our faces the other way, we must at moments admit to our minds something outside of this thing we have so falsely called space. If an angel from on high declared that space was a finite number of cubic miles, there is no mind on earth, from the lowest to the highest, in which there would not spring up, in spite of philosophy, the instant question, what is outside?

As to the possibility of a fourth dimension, there may be reason for further thought, but as to finiteness and curvature of space, true space, they are and always must remain impos-

sible for us. I know nothing, of course, of the reality underlying space, nor of the reality compelling the mind to form any mental object. It is evident that my mental perceptions are for me the only realities. It may be, as the idealists say, that I do not know whether I exist or not. But this I believe I do know:—if there be any realities, they are consistent; and the mental objects they compel, however different from the realities, are consistent among themselves. And I believe Euclidean space, being a transcendental intuition, will never be contradicted by any object the mind can form.

IS LIFE UNIVERSAL?

By J. Edward Chappel.

During the present generation there has been a great advance in our scientific knowledge of natural phenomena, and one result has been to render apparent the uncertain character of the ground of classification formerly believed to be secure, and especially has this been the case as regards the science of biology. The genera and species in which all known animals and plants were arranged during the first half of the present century, were at that time generally supposed to present well-defined characteristics by which their complete demarkation from one another was clearly established. But the later discovery of living and fossil intermediate forms, together with those supposed to have existed, which the doctrine of continuity demands, and of which many traces may yet be found in a fossilized state, have completely filled in the intervening spaces which formerly separated one species from another, and which gave to each its distinguishing features. As a consequence, we are no longer able to designate the boundary of a class, but are compelled to regard the totality of living things as consisting of a single system of diverging series, each unit of which differs from contiguous units only by an infinitesimal amount. Different

types are found to merge into one another by degrees so minute as to be imperceptible—what was once regarded as many we now recognize as one, and it follows that genera and species are indefinable; are in fact imaginary divisions of a single whole, being founded on distinctions purely fictitious. The sole difference of *kind* now recognized by the student of biology, who takes a broad view of his science, is that existing between forms of different origin. But as difference of origin means no more than being terminal forms of different lines of development diverging from a common source, it is evident that even here we have only a peculiar case of difference of degree, for by taking a circuitous route we may compass the space dividing the most dissimilar forms without encountering a break in the continuity of the connecting series. All so-called differences of kind among animals and plants being thus ultimately resolvable into differences of degree, in which are manifested attributes observed or believed to exist to some extent in all, it follows that classification of these forms can consist in nothing more than a process of arbitrarily dividing this single whole or series into sections or departments between which no distinguishing feature other than quantitative can be shown to exist, and even this quantitative difference is indistinguishable at the point of division.

Thus has modern science destroyed the very foundation upon which rested the traditional genera and species, and made apparent the artificial nature of all biological classification which takes into account the extinct as well as still surviving forms of living organisms. But the obliteration of ancient distinctions has by no means terminated here. The doctrine is now quite frequently advanced that the objects we call living beings are in their nature indistinguishable from the not-living out of which they have arisen, that here again we are dealing with a single and continuous whole, and that all attempts to classify individual forms in any other way or manner than that of arbitrarily dividing this progressive and connected series of forms must be idle and vain. No absolute or real difference between the living

and the not-living can be found upon which to base a natural classification, for the properties and movements which we denote by the term "life" are, according to our best information, not confined to any limited portion of the material world, but are attributes of matter in general. As the higher animal and vegetable forms are connected with the simple lump of protoplasm as displayed in the monera and myxomycetes by innumerable intermediate forms, so is that lump of protoplasm connected with the simple elements out of which it is built up. Below it exist forms of all lesser degrees of complexity down to the ultimate atoms of matter, and the protoplasmic cell but occupies a central position in the series as a whole, and is no less the product of development than is the primate or the oak. The higher or more complex inorganic forms are evolved from the lower, and, by a continuation of this same process, a complexity is sooner or later attained such that the term "inorganic" is no longer applied, and we call the aggregate organic. But precisely where in the series of forms the line between the inorganic and the organic should be drawn is a question which, if the doctrine of continuity be true, can never receive a satisfactory answer, for no one place can be designated rather than another.

Thus certain biologists, perceiving the necessity of the assumption of cosmical unity, and taking for granted the qualitative identity of the motions and manifestations presented by material forms of all degrees of complexity, refuse to admit the validity or rationality of any classification of these phenomena as living and not-living, but insist upon viewing the whole as a unit, rather than dividing it into sections the limitations of which cannot be marked off. Beginning with the higher so-called living forms with which their science deals, they occupy themselves in the study of those phenomena which are denoted by the term "life," and gradually descending the scale to forms of greater and greater simplicity, they find these manifestations, motions and changes still apparent. Though in ever decreasing clearness, at no point can they be said entirely to disappear,

XUM

nor, it is believed, would they be found wanting were it possible to extend our observation to the most minute particles, or even to the ultimate atoms out of which the material universe is constructed. This being the case, the denotation of the term "living" is extended beyond its former limitation, and made applicable to each and every constituent particle of the entire universe—the simplest, no less than those of vast complexity which constitute the higher living forms. "A more advanced science than ours," says M. Fouillee, "will find life everywhere." Not confined, as now generally conceived, to the animal and vegetable worlds, but a common attribute of matter in all its forms. "All matter lives," "all matter is alive," say various writers, and the animal and the plant display no qualities that may not be found in a less degree in the mineral or inorganic world from which they have arisen. All this, we are told, is implied by the misnamed doctrine of abiogenesis; and as this doctrine is a logical deduction from the general law of continuity, it seems likely to maintain its position as a scientific concept even though inductive verification be not forthcoming.

Logical and consistent as this line of reasoning apparently is, to accept the conclusion to which it leads is by no means imperative. There is another order in which the facts may be presented equally logical and consistent, but leading to what at first seems a quite different result. A philosopher, inclined to a synthetic rather than an analytic process of thought, might begin with the simpler material aggregates or minute particles of matter, observe and generalize the motions and changes there displayed, and advance step by step to the more complex, where the manifestations are displayed with ever-increasing diversity, until finally the higher forms of animals and plants were reached; and, as in descending so in ascending, nowhere would he encounter a break in the continuity of the evolutionary process. The course of development would appear continuous and uniform throughout, at no point giving place to sudden change or new agent, and at no point would the necessity of a change in nomenclature become apparent. If at the beginning he was to

name the subject of his study pure dynamics, pure dynamics it would be to the last, for he would be unable to discover a point where a transformation to something different could have taken place. The motions displayed in the higher aggregates of matter had their initial germs in the lower, and are in all respects essentially similar.

A higher organism is a phenomenon like other phenomena, acting and reacting in correspondence with surrounding objects, and to be observed and understood as these are. It differs from these other phenomena only in the degree of complexity of its composition and consequent complexity of reaction, and to this alone is due the greater difficulty of foreseeing what reaction will follow a given stimulus. "Did we fully know the whole history of the organism," says G. H. Lewes, "we could predict with absolute certainty what the response in every case would be." In the words of a famous living author, "man is but a highly differentiated portion of the earth's crust," and it is only because of our ignorance of the reciprocal relations of its multitudinous parts that we are unable to predict the reactions of a higher organism upon the application of a given stimulus with a certainty equal to that with which we may predict the movement of iron upon the approach of a magnet.

Thus we are led to a conclusion the exact opposite of our former conclusion, *viz.*, that in the whole scheme of nature no place for life can be found—only dynamics from beginning to end. That there is no such thing as life in the entire objective universe is a proposition that we may advance with as much assurance and as much justification as we may that other proposition, that "all nature is alive." But seemingly contradictory as these two conclusions are, they are, in fact, essentially the same. Their difference is a difference in terminology and nothing more. Both arguments alike are founded on the doctrine of continuity—the belief in the uniformity of nature; both insist on the identical nature of the phenomena in question, and the advantages obtainable by denoting a single class of phenomena by a single term. The dispute is merely verbal,

XUM

and no reason can be given why one term should be preferred to the other, nor is it of any importance which one of the two we accept.

But convenient and even necessary as a single appellative to denote what is common to both living and not-living may be on general considerations, separate terms denotative of different grades of the continuity can by no means be dispensed with. Admitting the vertical identity of what we call life and much that we call not-life, we may still insist upon the practical utility of separating them in our imagination by a broad and variable line of demarkation, covering a borderland of indefinite magnitude, and restricting the term "life" to those manifestations displayed by aggregates of relatively greater complexity, even though such restriction be avowedly arbitrary. This indeed may be no less necessary for the purpose of faciliating our study of nature than is the similar artifice of drawing such fictitious distinctions as those between the adult and the child, the large and the small, and the like. The terms are purely relative, denoting different degrees of the same thing, and, if recognized as such, to insist on speaking of a molecule of silicon as living because it displays in a less degree the same active properties displayed by the higher organism, must seem no less absurb than to insist on calling a dwarf a giant because the two differ only in size. There are various colloidal substances, as pitch or asphalt for instance, which pass from a liquid to a solid state by insensible gradations. Are we for this reason driven to the conclusion that these substances are always solid, or always liquid? If not, why are we forced to admit that matter is always living, or never living? It is only when the fact of the dependence of the terms on one another for their meaning is ignored, and an absolute distinction implied, that we can reasonably object to the use of a plurality of names to denote the different degrees in which similar phenomena present themselves to our observation.

If, however, this argument be deemed unsatisfactory; if it still be asserted that, since we recognize the protoplasmic cell

as occupying a middle station in the series of forms displaying the phenomena in question, we are bound in consistency to apply the term denoting these phenomena to all parts of that series; even admitting this to be true, still we are not forced to the conclusion that "all nature is alive." There is another plan upon which objects must be classed as living and not-living, a plan which does not conflict with the doctrine of continuity in the least—where the distinction is a real distinction, and where the classification is one of which we must admit the validity—however much we may believe in the universality of life. Every object of which we have any knowledge or conception consists of an aggregate of parts. Where the object is living these parts are mutally dependent, and act in a manner conducive to the welfare of the aggregate as a whole. Even where there is no visible structure and apparently no division of labor, this statement holds good. But with *all* aggregates of matter the parts are not thus coöperative. Here then we have a distinction upon which we may base a definition of life not subject to the charge of assigning arbitrary limitations; a *bar* of steel is not alive, whatever may be said of its constituent particles. Though a believer in "panbiotism" may tell us that a molecule of iron or carbon, an amœba and a vertebrate, are all alike living things, yet he will hardly say the same of a *lump* of charcoal or a diamond. Though he may maintain that the molecules of hydrogen and oxygen are as much alive as the more complex protoplasm, yet he will not speak of a pebble or a block of ice as a living thing. Thus we may admit all these biologists can demand and still have a class of objects—aggregates of matter—which, considered as aggregates, certainly cannot be said to live. An object, then, is alive only when its several parts coöperate to promote the welfare of the whole. Objects not coming under this definition must constitute an opposing and correlative class—the not-living.

But, after all, may not this argument for the universality of life, even when thus qualified, be indefensible? Is it not based upon an unverified assumption which may some day

prove contrary to facts? It is true that in the present state of our knowledge we are unable to discover a point below which the manifestations of life entirely disappear, or to distinguish these manifestations from those of matter in general. But this does not prove that no such distinctions exist—that with additional knowledge we may not be able to discover some definite point where life ceases, and below which the movements and changes of matter are of a quite different order. Not every liquid in passing to a solid state passes through all degrees of viscosity, as do the colloids. On the contrary, the crystalloids apparently pass from the one to the other state by a sudden leap, and, though as yet unobserved, something of an analogous nature may accompany the evolution of living forms from not-living matter, and may have accompanied the first appearance of life.

Here, also, the particles may suddenly assume a definite structural arrangement in the aggregate, and if this be the case, we may expect to find the actions and reactions of the body possessing this structural arrangement of parts to differ as greatly from those of a body composed of like parts not thus arranged, as the actions and reactions of a drop of water differ from those of the same aggregate in the form of ice. It is by no means inconceivable that further investigation, conducted under more advantageous circumstances, may result in disclosing such a difference between what is commonly called life and a lower form of molecular energy. And until such investigation has been systematically carried out to the obtainment of definite results, we must be content to remain in a state of uncertainty as to whether life ever had a beginning in time, or whether it is eternal and universal.

THE BRAIN IN THE LIGHT OF SCIENCE.

By S. Millington Miller, M.D.

The researches of the last thirty years have vastly increased our knowledge of the general topography of the central nervous system. Before that time the brain was regarded as an organ with a single office to perform—that of thought. But Broca, Goltz, Hitzig, Ferrier, Horsley, and a long line of painstaking and laborious experimentalists, have succeeded in localizing the sense and motor-centres in the cortex of the cerebrum. A reasonably adequate ground has thus been afforded for our knowledge of exactly where certain functions are performed.

But those intellectual processes which go by the name of "thought," "volition," "memory," "the association of ideas," etc., have not yet been explained upon a basis of pure physical science. The trend of modern physiology points unquestionably, however, in one direction, and indicates the possibility of a physical explanation of the mechanism of intellection.

That the subject may be thoroughly understood before the attempt is made to draw conclusions therefrom, I will set down as briefly and as tersely as possible just what the experimentalists above noted, and other laborers in the same vineyard, have definitely discovered.

NERVE CELLS AND FIBRES.

The whole nervous system consists of cells of different shapes and sizes connected with each other by fibres of microscopical diameter. Nerve trunks are simply bundles of fibres held together by a restraining sheath. The cells which seem to play an active part in the processes of sensation and intellection are what are known as multipolar cells, or cells with many irregular prolongations. These cells are a higher development from round embryonic cells. Each of these multipolar cells consists of an irregular sac filled with

granules and containing within itself a nucleus. Within that still is a nucleolus. These nuclei and nucleoli form the famous "protoplasm" of Huxley—"the physical basis of life." It is by the division and subdivision of these protoplasmic elements that such a thing as cell growth is possible. Wherever any so-called ultra-physical process is to be performed there these cells exist.

The fibrillar prolongations of the rods and cones of the retina end in these multipolar or spindle cells, as they are called, and in them begin the fibres of the optic nerve. The fibres of this same optic nerve end in similarly shaped and constituted cells in the cortex or rind of the cerebrum. Similar cells form the so-called motor centres in this same cortex. These motor cells are connected on the one side with the sense cells by fibres, and on the other side by fibres with the "end plates" or central nuclei of muscular fibres all over the body.

These nerve fibres are in all cases a simple prolongation of the poles of the cells. Retinal cells, and sense cells, and motor cells, and muscle cells, are therefore in one continuous channel of communication. I cannot more distinctly describe the whole system than by likening it to a long and tortuous canal which widens at certain places into a lake-like expansion—each such expansion having an island in its centre, and each island having a central distinctive point, such as a house or tower. The islands are the nuceli of the cells, and the houses or towers their nucleoli. These nuclei and nucleoli bear the same intimate relation to the processes of sensation, thought, and volition, which occur in the brain, as may be supposed to be exerted by the islands, or by their inhabitants, on the system of transportation along the canals and through the lakes.

It will thus be seen that the entire extent of the axis-cylinder (tube) of the fibres and of the contents of the cells consists of plasmic and semi-fluid material admirably adapted to carry electrical waves from the surface, through regulating or modifying centres, and so out again to the periphery.

FUNCTION OF NERVE CELLS.

It is plain, from what I have just written, that what we know as "volition," "thought," and "perception," take place in the central grey matter cells of the cortex of the cerebrum. The simplest function of such cells is that performed by them in the reflex-centres of the spinal cord. If I sit down upon a chair from whose seat a pin is projecting, the sensation of pain is carried to my brain along one of the fibres of the spinal cord. But the same sensation is carried at the same moment to a reflex centre in the spinal cord, from which a message goes out instantly, causing the muscles of the lower part of the body to contract and lifting me out of the chair. Much the same office is performed by those cell centres in the cortex to which the optic nerve carries the sight of a falling brick. The reflex of this impression causes the threatened portion of my body to be immediately removed from the path of the falling object. It is easy to understand this reflex action to be a purely mechanical one, by which an impulse of sight is simply changed at the centres into an impulse which produces muscular contraction. But those processes by which we reason from our perceptions of sights and sounds, and by which a complicated thought, or series of thoughts, is deduced, is not by any means so easily explained. Still we have the fact to assist us in the inquiry, that whatever does actually take place either originates in one of these cells or is evolved by the associated action of a number of them.

FUNCTION OF NERVE FIBRES.

The afferent fibres, which carry sensations to the sense-centres in the cortex, and the efferent fibres, which connect those centres with the protoplasmic elements of the muscles, differ only in their capacity to transmit impulses in different directions. The first from the periphery to the centre. The second from the centre to the periphery.

The experiment has been tried of denuding the tip of a rat's tail, and suturing this denuded tip to the centre of the rat's back. As soon as the tip heals in place the base of the

tail is severed from the rat's body. When this raw base is irritated the rat has the same sensations of pain as it did when its tail was normally connected with its body. What is more, it is now the broad end of the rat's tail which curls up. In other words, the nerve fibres of this tail, which first carried the sensation inward, now carry the order for motion outward, and *vice versa*. It is therefore plain that these microscopical nerve fibres bear exactly the same relation to sensations of sight, or of hearing, or of pain, and to orders consequent upon such sensations, as does the iron wire to the electric current, which it carries equally well in both directions.

FUNCTION OF MUSCULAR CELLS AND FIBRES.

In order to produce that effect which is known as muscular contraction, it is necessary that a sudden or more powerful impulse shall be sent out through the axis-cylinder of the motor fibres. Regular and constant vibrations in this nerve conductor paralyze a muscle in time, or inhibit its powers of movement. This principle is exactly the same as that which holds when a person who lives beside a noisy railway loses in time all conscious sensation of its sounds, owing to their constant occurrence; or as a person who sits in the room with an incessantly ticking clock is entirely oblivious of its ticking. It is this principle also which is employed by the hypnotiser who produces inhibition or paralysis of sense-centres by causing the eye to be steadily concentrated upon a brilliant or rapidly-moving object, or who makes rhythmical passes or strokes until the regularity of sense impulses lulls the sense centre to sleep.

As regards the fact of muscular contraction itself, the leg of a beetle has been placed in the field of a microscope and the contraction of its muscles rendered visible to the human eye. In this way it has been found that that process which goes by the name of muscular contraction consists entirely in a change in the relation which the protoplasmic elements of the muscle bear to each other. A long and thin fibre is changed by a rhythmical wave of so-called contraction

into a short and thick fibre. Originally each protoplasmic constituent of the fibre was long and thin, and nervous excitation has rendered each short and thick.

CEREBRAL LOCALIZATION.

The united efforts of clinicians, pathologists, and experimentalists have succeeded in affording a fairly adequate idea of exactly where certain motor and sense functions are located in the cortex of the cerebrum. This result has been attained partly by the vivisection of the dog and monkey, and partly by a close study of the symptoms and pathology of diseases and tumors of the brain.

By following these combined lines of thought, the conclusion has been reached that the various centres of motion lie under and adjacent to the fissure of Rolando, and that the centres of sense, or, to particularize, of sensation in general (or touch), of vision, of olfaction, of gustation, and of audition lie behind the motor centres in various portions of the cortex of the occipital lobes of the cerebrum. The "general sensation" centre has been located nearest to the fissure of Rolando. The fact that motion follows much more rapidly after the sensation of touch than after that of sight, explains the relative nearness of the two centres to the motor centres. The investigations of Broca point to the frontal lobes of the cerebrum as the centres of thought and speech. The pathology of aphasia, and the deficiency of these frontal speech centres in the dumb, point in the same direction.

A case illustrative of these discoveries will be in point. It has become quite common in recent years for surgeons to remove certain portions of the brain in such cases of epilepsy as have been shown to be due to irritation originating in these specific centres. Dr. W. W. Keen, of Philadelphia, recently saw a patient whose epileptic attacks invariably began with twitching in one thumb. This fact was well authenticated by the most painstaking and repeated observation. It was decided to remove the thumb centre from that side of the brain opposite to that of the affected thumb. The bone was trephined, and after the centre had been local-

ized by electrical stimulation, it was cut down upon and removed with the scoop. As is always the case with operations upon the brain, there was but little bleeding, even less pain, and a speedy recovery from the operation, with no unfavorable symptoms. The patient was at first entirely relieved of her epileptic attacks (although they finally recurred), their severity was mitigated and they were far less frequent. This was an operation of remarkable nicety, as the entire substance of the "thumb-centre" had to be removed without including any of the other various finger, wrist, elbow, shoulder or face centres which impinge upon it on all sides.

Dr. Keen has also performed a similar operation for removal of the "hand-centre." The patient was a boy whose attacks always began with twitching of the members of one entire hand. He recovered promptly from the effects of the operation and was free from attacks for some time, but eventually suffered again from them to a very limited extent.

THE VICARIATE OF THE CEREBRAL HEMISPHERES, OR THE REGROWTH OF REMOVED PORTIONS.

A consideration of cases such as the above very naturally leads up to the question which I have just propounded. Is one cerebral hemisphere able to perform the duties of the other when it has been injured, or does brain tissue, when removed, quickly replace itself by a new growth? It is not at all unlikely that both of these horns of the dilemma are true. Immediately following the removal of a thumb, or finger, or hand centre, etc., it would appear that its office is performed by the corresponding centre on the opposite side of the cerebral cortex. Numerous reports of surgical cases are on record in which considerable destruction of tissue on one of the cerebral hemispheres has not visibly interfered with the performance of normal brain functions. Certainly this would be the natural conclusion from observations of the fact that epileptic attacks disappear almost entirely for a longer or shorter period immediately following the excision

of a diseased centre, but that they finally recur, though with diminished severity and frequency.

Nowhere is the force of "tissue-habit," if I may use the expression, so marked as in the substance of the brain. A centre somewhere in its body has formed the *habit of disease.* This habit shows itself in twitching of the thumb or hand. If excision were performed at an early stage of the disease, it would be fair to presume that the habit had not yet been thoroughly formed, and that when new cells proliferate and form a new thumb centre after the removal of the affected one, this habit reinstates itself with just about the same amount of intensity which it originally possessed. Previous to the formation of the new centre by this growth of new brain tissue, the function of the diseased and now removed centre was performed by the perfectly healthy centre on the opposite side of the brain, and as long as this went on there was no recurrence of the disease.

Corroborative of what I have just set down is the well-established fact that the success of operations upon brain tissue depends very largely upon the period in the course of the disease at which they are performed. If epilepsy, originating in the "thumb centre," were treated at an early stage by removal of that centre from the brain, the recollection of the habit of disease would be very slight in the new thumb centre soon formed, and *vice versa* if it were performed at a late period in the disease. I will have more to say hereafter of *this force of habit* as partially explanatory of very many somewhat obscure functions of the brain.

THE CONSTITUTION OF THE BRAIN.

The brain of highly intelligent adults consists, as I have already explained, of an enormous number of cells of different shapes and sizes, connected with each other and with the "end-plates" in the muscles by an equally enormous number of fibres. The grey matter cells occupy the entire substance of the cortex of the cerebrum, and the white substance of its body is entirely composed of connecting fibres. A microscopical view of this cerebral body gives one very much the

impression of a marvelously equipped and powerful dynamo —numerous and confusing bunches of wires, or fibres. These fibres not only connect the various centres of sense in the occipital cortex with the centres of motion under and around the fissure of Rolando, and join these motor centres with the "end-plates" in the various muscles of the body, but there are also a very great number of other commissures connecting the sense and motor centres in the occipital cortex with those higher centres in the frontal cortex in which the finer processes of speech and mentality are now supposed to reside.

If there were one large cell where impressions of sight were received and modified, and one where they were acted upon by that process which we call thought, it would be far more necessary to predicate the existence of some entirely ultra-physical form of energy in that centre which was able to elaborate impressions of sense into conclusions of thought. But a diametrically opposite condition of affair is present. Thousands and thousands of rods and cones exist in the retina of the eye. An equal number of multipolar cells in the floor of the retina modify the vibrations of sight so that they may proceed to the centre of vision in the cortex of the cerebrum. In this centre thousands of multipolar cells, each connected with a separate cell in the retina on one side, and with a separate cell in the frontal cortex and the motor centres on other sides, change by some as yet unknown process impressions of sight into thought, volition, memory, muscular action.

In the same way thousands of hair cells in the endolymph of the cochlea receive the waves of sound, which are reconverted into electrical impressions by the spindle cells at the bases of these hair cells. These impressions are then carried through a vast number of fibres to an equally great number of multipolar cells in the centre of hearing. And these cells in the centre of hearing are connected on all sides in a similar manner to the cells in the sight centre. This same truth holds in regard to the manner in which other impressions of sense are received, conveyed and elaborated.

XUM

The argument from analogy is, therefore, so strong as to be well nigh conclusive that there is some connection between the great number of centres in which sensation and thought are received and elaborated, and the great number of sights and sounds and tastes and smells which travel momentarily up into the brain through the portals of sense.

SLEEP.

The endless activity of the sense centres and of those of intellection during the waking hours gives rise to a natural weariness or exhaustion, and sleep comes on. Sleep, in other words, is a word employed to describe a total condition of paralysis or inhibition in which all the centres of the brain participate. As the fibrillar connections of these various centres are simply conductors and not originators, they naturally participate in the same condition of repose. The brain being formed, as already described, of a vast number of centres where various functions are performed, it naturally follows that sound and healthy sleep should affect all portions of the brain equally, and this is the case.

DREAMS.

This expression merely indicates that while the sense centres are fatigued (temporarily inhibited), the higher centres of intellection, though doubtless equally fatigued, are still carrying on an independent series of procedures entirely irrespective of the outer world. This is, of course, an unhealthy condition of these higher centres, and due altogether to some anomalous state of affairs, such as disturbance of the circulation or nutrition, or something of the kind. As the will has its domicile in some of these centres, its action, even in sleep, upon the motor centres, gives rise to restless movements of the body or members.

HYPNOTISM.

This is artificial inhibition of all the sense centres, except that of hearing, produced by the mechanical methods already described. Employing the auditory nerve as a channel of communication with the higher centres in the

brain of the hypnotized subject, the operator sends impulses of his will along the fibres of the auditory nerve, through the contents of the centres of hearing, and through the fibres which connect them with the higher intellectual centres. The volitions of his mind act directly, therefore, upon these higher intellectual centres in the hypnotized subject, and rouse them into pronounced and distinctive action. The *rationale* of this method of procedure indicates emphatically that the hair cells in the cochlea, upon which wash the sounds of the hypnotizer's voice, are directly connected with every other part of the brain. It is also clear that the centres of hearing, or their nuclei and nucleolei, are performing no independent processes of their own. In other words, that the hypnotizer has the exclusive use of uninterrupted pathways to the thought centres of the brain, and that his voice, or rather the impulses to which it gives rise, are carried right past otherwise active and potential centres without any interference on their part.

BRAIN SIZE IN RELATION TO INTELLIGENCE.

As many intelligent persons have remarkably small brains, and as unusually large brains are not uncommon among idiots, it is evident that the amount of intelligence does not depend on the gross size of the brain. The mental supremacy of man over the invertebrate and in the vertebrate kingdom shows itself in the relation borne by the cerebrum to the other parts of the brain. Whales and elephants have very much heavier brains than man, but the development of the inferior or cerebellar portion of the brain in these vertebrates is out of all proportion to that of the cerebrum. Whereas in man the cerebrum is always much larger and heavier than the cerebellum.

In the child, at birth, the surface of the cerebrum is smooth, but as it grows older the convolutions are formed by the indention of fissures which greatly increase the cerebral surface of the brain without a corresponding increase in the size of its bony casing. Depth of brain fissures has been always found to accompany highly developed minds. It

will be seen that extent of sensory, motor, and intellectual surface is thus acquired with the utmost economy of space capacity.

AMOUNT OF BRAIN SUPPLY REGULATED BY REQUIREMENTS OF SENSE DEMAND.

As the growing child is brought into closer and closer connection with the facts of the outer world—as its perceptions become more intense—a double process occurs in the cortex of its cerebrum. And this process continues uninterruptedly and *pari passu* with the development of intellectual life. The first change noticeable is that the round embryonic cells develop into multipolar or spindle cells with the manifold nerve fibre connections previously noted. Nor is this all. New cells are constantly being secreted or formed in the cortex of the cerebrum, in accordance with the growing demand for them by the processes of sensation and thought.

It is therefore plain that the brain is not full formed at birth—a house ready built and furnished, into which

> "The soul that rises in us
> Our life's star——"

moves as a first occupant. If there be any such thing as soul or mind separate from brain, it is assuredly of very small amount at birth, and finds little, if any, promise of the manifold complexity of its future mansion. It seems to be an undoubted fact that each new sensation of the growing child demands the development of its particular storehouse, and, as sensations are classified and elaborated into memory and thought, that this same process of house-building goes on in the higher frontal centres of the cerebrum.

THOUGHT SIMPLY A HABIT OF NERVE CELLS.

Little, if anything, has been written on the tremendous part played by habit in the lower and higher processes of the brain. Perhaps the most striking illustration of this force is what is generally known as "presence of mind." The least amount of thoughtful consideration will prove to the most skeptical that this condition of affairs does not

originate *de novo*, that it is nothing more or less than the result of constant practice.

The most alert and serviceable mind is undoubtedly that which accompanies a perfectly healthy body. Deficient or ill-regulated food supply, unfortunate environment, disturbances of digestion, or of circulation, or of any normal secretion, renders such a thing as "presence of mind" absolutely out of the question. But given a child born of strong and intelligent parents, and under the intellectual supervision of a decided and intelligent mother, mental readiness is something of easy acquirement. The child learns altogether by imitation, and its first efforts in this line will be an exact copy of the mental processes of its educator. And that educator's will, in the shape of commands given to the child, must be exerted in the line of prompt appreciation of sensations and correct and immediate motion or action based upon them.

The power to act instantly in the wisest and most serviceable manner is impossible as an unpredicated action. If presence of mind were due to a something called "intelligence" inhabiting the brain, but apart and entirely distinct from its structure, prompt action might reasonably follow as a primal act, but all analogy proves that this is not the case.

I do not propose even to attempt such a thing as a complete and satisfactory explanation of the entire mechanism of thought, but a brief *résumé* of the various points raised in this paper will certainly be brimful of suggestiveness. We find that the nervous system consists of a continuous passageway from periphery, through centres, and out again to periphery. Part of this passageway is formed of simple conductors, the nerves. At certain points in the channel exist certain cell centres, possessed of a central potentiality, in the shape of a nucleus and a nucleolus. The conducting fibres begin in cells in sense fields, end in cells of muscular movement, and connect those cerebral cell centres where sensation is elaborated with those higher frontal cell centres of the cerebrum where thought is performed.

This pathway of perception and intelligence is a matter of constant development, and does not exist before the requirement for its use. The higher centres of will, or those from which the orders come which cause muscular movement resulting in actions, or in speech, are cut off by hypnotism and in sleep from their conscious connection with the centres of sensation, and may be formed by the volition of an entirely distinct individual. This alien volition reaches them as an electrical current sent through the fibres of the auditory nerve. Or the pole of a battery applied to them will not only cause movement of the coarser muscles, but also give rise to vibrations of the vocal chords, producing what is known as speech. This entire line of *thought* would indicate that that form of molecular motion and interaction—which we designate by electricity—is at the root of every function of the brain, and the fact that the infinite complexity of action in many cases clouds our understanding of the *modus operandi* is no reason why we should not struggle to follow the clue to its legitimate goal, rather than call into service a spiritual something whose method of procedure is entirely outside of the sphere of either sensation or thought.

The writings of Tyndall afford an explanation of the correlation and conservation of forces, and show how one force is transformed into another.

Let us take, for instance, the sensations arising from the examination of that object which we call a book. Its mental effect would be exceedingly vague in the child at birth, or, to be more exact, soon after birth; even more so than those perceptions which come to us so sluggishly as we waken from sleep, or which are so indistinct and glimmering just previous to death. In the latter instances the appreciative centres are either coming out of *inhibition*, or are disintegrating forever. But in the infant they have not been fully formed. As the child grows, however, a long series of imitations and the formation of distinct mental habits lead up to the consummate processes which I will endeavor to detail.

XUM

A book lies upon a table. The waves of ether dash its shape upon the image field of the retina, whose nerve cells change light into electricity, and transmit the sensation in the direction of least resistance—which means by one particular fibre to one particular sense-centre cell. At this particular sense-centre another transformation of energy takes place, which (further modified, perhaps, by a motor centre) sends out an order to the muscles of the hand to lift and open the book. It will be noticed that just one series of fibres and centres is employed in this act, and that what these centres accomplish is nothing more complex than a transformation of one form of energy into another—in one particular way—the habit of which has been forming ever since infancy. In other words, this particular chain of consequences is imperative, for it has been forged by imitation and it has been linked by an infinite number of repetitions of the same action.

But there are higher functions involved. A certain fibre or set of fibres connect the centre where the sensation is received with a centre, or centres, of speech in the frontal convolutions, and these "speech-centres" are connected by fibres with the muscles of the vocal chords. It is quite within the range of conjecture that each vowel and consonant and word sound have specific nerve cells as their storehouse. And electrical movements proceeding from the cell, or cells, of sense by the way of least resistance, which is the old-established channel, reach certain frontal cells and are reconverted into new forms of motion, producing a certain movement of the vocal chord which gives rise to the sound "book."

This whole series again is, in a certain way, just as simple as the original "seeing, lifting and opening" process. It has been acquired by imitation, and has become fixed by habit, and the sound "book" is just as certain to be thrown up as are the corresponding letters to be printed by the proper fingering of the typewriting machine. It should be remembered in this connection that we hear the

word book in the brain when we see a book, although we may not articulate the sound.

The great difficulty experienced in writing on this subject, or, what comes before writing, in thinking on this subject, is in itself the strongest kind of proof of the truth of my explanation. Channels opened up by imitation and beaten by habit are such easy pathways of thought that the action is sometimes unconsciously performed. But where the journey of the thought wave is made for the first time, it has to build its own channel, and meets all kinds of obstacles in the way. And it takes repeated effort and a longer or shorter period of time to construct the road.

The rapidity with which a date or a name is "remembered," as we call it, depends entirely upon the amount of impression first produced by it; in other words, upon the number of trips that the original impression has made from its source to its point of reception and storage. And when we try to remember a date, or a name, the process which is pursued in the brain may be very reasonably likened to the dilemma of a stranger, walking through the woods, upon reaching a point where his one path branches out in every direction, and he has a dozen paths from which to choose. He may have to try each one of them before he reaches his objective point, or he may find that none of them will take him to it, and be compelled to strike out anew for himself in the desired direction.

This is just the reason why the recollection of a poorly impressed name or date requires a longer or shorter time for its discovery. Something has excited the original sensation in its original centre of sense, but the current of perception, reconverted into another shape, runs down this fibre and that, and still others, only to find them all the wrong pathway. And unless that first faint trail can be found, an altogether new fibre is called into being, or into play, and a new storage centre found or formed, and this naturally takes time. The time in this case is properly known as "racking the brain," which means nothing more or less than the birth pang of a new avenue of energy and of a new storehouse of facts.

XUM

I desire to call particular attention, in conclusion, to a very interesting and suggestive paper which appeared in the October number of THE NEW SCIENCE REVIEW, on "Defective Methods of Mental Training." In this paper the necessity for the thorough impression of an object on the mind is admirably discussed, and the plea is made that the mind be saved from the impression of such objects, or from such impressions of certain objects, as may be absolutely useless for purposes of memory and talk. I also call attention to Mr. Edison's discussion of the distinct individuality and individual intelligence of atoms.

EVOLUTION AND TELEOLOGY.

BY F. H. PERRY COSTE, B.Sc., F.C.S., F.L.S.

"In the formation of species, Nature gets as it were into a cul-de-sac; she cannot make her way through, and is disinclined to turn back." GOETHE.

It is a very common remark, and one that has been exemplified again and again in the history of philosophy, that any old and widespread belief dies hard; and that, even after it has apparently received its death-blow, it lingers on in some subtle disguise as an influence for evil. When the theory of evolution was first propounded, it was assailed with every species of abuse by those who were officially bound to defend the old theological views. Now, however, that evolution is fairly established and dominant, theologians have discovered that this theory of evolution was the one thing needful to complete the demonstration of their doctrines, and to prove the inevitable "ascent of man" and, indeed, of all organic life; for it cannot be denied, that, in the popular view, evolutionism teaches not only that the higher species have been evolved from the lower, but that there is also an universal tendency to such progress; indeed, among the uninstructed, any instance of stationary or retrogressive organisms is seized upon as an argument fatal to

evolutionism. Of course a great blow was dealt to this progress-tendency-view by Dohrn and Lankester in their works on "Degeneration," so that nowadays every competent botanist or zoölogist is fully alive to the important part played by this factor; and, given a series of organisms, he is not content with merely showing their generic relations to one another, but must also inquire whether this relation be one of ascent or descent.

Yet notwithstanding the immense influence that we must ascribe to degeneration as a factor in evolution, and we cannot but think it more than probable that as yet we have by no means exhausted the catalogue of its examples, it is well-known that several biologists still attribute to organic life a tendency—an inherent and essential tendency—to progress and to evolve into higher forms. It is notorious that this view—which Weismann, as he himself remarks, has for years made it his business to oppose—was held by that splendid botanist Nægeli; and from him it has been adopted, more or less confidently, by Dr. Vines. It must be admitted that we are in a singularly unfortunate position for criticising such a theory; since in the main we know only those types that have progressed to at least some extent, but cannot tell what proportion of failures may have been swept away for good and all. When we start at the top of the shoot that has been struggling up, we naturally credit such shoot with an inherent tendency to rise; but, to judge fairly, we should start at the bottom and ascertain how many shoots have taken other directions and failed. So far, however, from there being any such innate irresistible tendency to progress, it is well-known that the higher evolved is an organism, the more narrow and rigid are the limits within which it is able to vary, and therefore to progress. The capabilities for progressive evolution of a fish are vast; of a mammal far fewer; of a man almost none.

Now it has often seemed to us that few things are more instructive to observe than the phenomena of *blind alleys* in evolution—the evolution, we mean, of certain groups along lines which then stop, as if the capacity for farther evolution

were wanting. These blind alleys are particularly well exhibited in botany, and are of great value in connection with Nægeli's theory. We have elsewhere had occasion to point out the radically unphilosophical view that students are apt to form when they are taught that higher groups are evolved from lower, which they take to imply that the highest species of Group A have given rise to the lowest of Group B, and so on; whereas, this directly linear evolution is not that which we find commonly to occur. Now within the last few years there have been published in the botanical journals several highly important and interesting articles, which seem to us admirably to illustrate the statements just made concerning the frequency of these blind alleys and their important bearing on Nægeli's theory. Since the matter is one of very great scientific importance, quite apart from its special botanical interest, it has seemed to us that a brief *résumé* of the results, regarded in this light, would be acceptable to those readers of this journal who, not being botanists, are little likely to have seen the original articles. It will, of course, be understood that, although for the data we are in no wise responsible, since we are drawing upon papers by Mr. Bennett[1], Dr. Campbell[2] and Prof. Bower,[3] in addition to such results as were previously common property; yet for certain deductions from these results we must take the full responsibility. Perhaps it may be advisable, in order to facilitate the comprehension of our argument, to briefly outline the usual botanical classification. Starting then from the bottom, we have four great subdivisions of plants, *viz.:* Thallophyta, Bryophyta, Pteridophyta and Phanerogams. These are again subdivided—the Thallophyta into *Algæ* (Green *Algæ*, Brown and Red) and *Fungi*, besides the two lowest groups of *Cyanophyceæ* and *Schizophyta*. Into the somewhat intricate and debatable genealogical relations of the *Fungi* we do not propose to enter, and

[1] Linn. Socy's Jl. (Botany), Vol. XXIV.

[2] Annals of Botany, Vol. VIII, and Science Progress, 1894, and Botanical Gaz., Vols. XV and XVI.

[3] Ann. of Botany, Vols. III and V.

it will therefore be unnecessary to detail the various subdivisions of this group; but we may point out that, anyhow, the whole group has been evolved along a blind alley, which leads on to no other and higher form, and of which the *Basidiomycetes* are usually regarded as the terminus. It is, however, only fair to add that, according to the opinion of both Weismann and Vines, this failure of the *Fungi* to attain a higher development is probably largely attributable to their asexuality, so that they are not therefore entirely on a par with the chlorophyllous plants, to the consideration of which we shall now proceed.

With regard now to the *Algæ* we may consult Mr. Bennett's paper. After assuming that vegetable life shows three distinct phyla, and that the first, commencing with the *Schizophyta*—which are, however, probably retrogressively derivative—soon ended abruptly in the *Fungi*, he proceeds to examine the development of the second and third phyla—the *Cyanophyceæ* and the *Chlorophyllophyceæ*. The second, he thinks, ended in the divergent families of the *Syntonemaceæ* and *Nostocaceæ*, whilst all the vast variety of the vegetable kingdom otherwise rises from the third primal stock of the *Chlorophyllophyceæ*. Whether this theory of the rise of plants be, or be not, finally confirmed, we can at least draw a very significant moral from the fact that the theory admits of being seriously advanced. If it be valid, then, so far from finding the Nægelian inherent tendency to progress, we shall have to admit that a potential two-thirds of the vegetable kingdom ended abruptly in very low forms almost before advance had begun!

Turning now to the *Chlorophyllaceæ*, we find that from the primeval group of the *Protococcaceæ* Mr. Bennett derives four lines of advance, two of which have ended abruptly in the *Eremobiæ* and *Diatoms*[1] respectively, whilst a third developed as far as the *Volvocineæ* and *Hydrodicteæ* and then also stopped.

[1] The position of the Diatoms is very doubtful. Mr. Bennett suggests that they may be the "abrupt conclusion" of a branch from the *Cyanophyceæ*; and, as will be seen, he has a third possible descent for them.

The fourth line, after splitting off a branch which ended in the *Siphoneæ*, etc., produced the isogamous *Confervoideæ;* and from these Mr. Bennett again derives three lines of ascent: one the *conjugatæ* which there terminated, possibly, however, giving rise to a retrogressive development ending in the Diatoms; a second rising as far as the specialized *Fucaceæ* from which line also there are various retrogressive developments; while the main ascent continued through the heterogamous *Confervoideæ*. From these are derived again one branch ending in the red sea-weeds (*Florideæ*), also giving rise to retrogressive forms such as *Bangia*, while the other branch splits again, giving rise, on the one hand, to the line which passing through the *Characeæ* ends in the *Muscineæ;* and on the other hand to the main line of development through Pteridophyta. If now the various branches here referred to be counted, it will be found that, putting aside altogether the two assumed primeval stocks of *Schizomycetes* and *Cyanophyceæ*, there are in the *Chlorophyllaceæ* themselves at the very least eight blind alleys. So that, according to these views, out of eight separate lines of evolution which we see starting among the Thallophyta, seven proved blind alleys, and one only brought forth higher forms than Thallophyta! Here we gratefully take leave of Mr. Bennett and pass on to the next two groups, the genealogy of which has been the theme of several important memoirs by Prof. Bower and Dr. Campbell. Of these, the Bryophyta are divided into two subgroups, *viz.*, the *Hepaticæ* or Liverworts, and the *Muscineæ*, which latter consist of the *Sphagnaceæ* or Bogmosses and three families of true Mosses; while the Pteridophyta comprise the distinct groups of *Filicineæ*, *Equisetineæ* and *Lycopodineæ*. In approaching this part of our subject, we are treading upon delicate and somewhat debatable ground, where we are troubled by the *embarras de richesses;* and the genealogies, to which we are about to refer, can hardly be considered at present as more than working hypotheses. For our purpose, however, which is to present certain philosophical aspects of botanical evolution, it is of little import

whether the genealogies at present in favor should suffer fresh metamorphoses or not; since the trend of research is to increase rather than to diminish the number of blind alleys.

Now, as we have already seen, Mr. Bennett provisionally places the *Muscineæ* at the end of a blind alley approached through the *Characeæ*, and places the Pteridophyta upon a somewhat different line of evolution. There can be no doubt that the higher Bryophyta, anyhow, both the *Hepaticæ* and the *Muscineæ*, but especially the *Muscineæ*, are terminals of blind alleys; but it is far from certain that the connection between the primitive forms of Bryophyta and Pteridophyta is so distant as would appear from Mr. Bennett's tables. Be that as it may, the termination of the higher Mosses in a blind alley follows equally from the theory originally supported by Bower and Goebel that the Pteridophyta were developed from the *Hymenophyllaceæ*, which they derived from alga-like forms of branched filaments; from Goebel's suggestion that the Mosses are descended from a form like *Buxbaumia*, which was closely related to the lower *Algæ* (note here again how this emphasizes the blind alley development of the whole vast class of the higher *Algæ*); and from the theory of Dr. Campbell to which Prof. Bower is now inclined to assent, at any rate provisionally.

According to this latest view the *Eusporangiate Filicineæ* (*Marattiaceæ* and *Ophioglossaceæ*), which were formerly thought to rank at the very top of the *Filicineæ*, and to be derived from the Leptosporangiate forms through the *Osmundaceæ*, and to form the transition *at the top of the stem* from *Filicineæ* to *Cycads* (the lowest forms of *Gymnosperms*), are now derived direct from a lower form of *Hepaticæ*—the *Anthoceroteæ*, to wit—which is itself derived from some such form as *Coleochæte* among the *Algæ*. This very strikingly manifests the blind alley character of not only the *Muscineæ*, but also of the higher *Hepaticæ* too, as well as of course of all the higher *Algæ* to which *Coleochæte* may have given rise. But this is not all. The Cycads are thought to be derived from *Marattiaceæ* through *Isoëtes*—this line of development

also terminating apparently in another blind alley—whilst the great group of *Leptosporangiate Filicinœ*, the "true ferns," are regarded as a specialized and comparatively recent development from *Marattiaceæ* through *Osmunda*. This being so, it is clear that the *Filicineæ* are not merely a blind alley, but rather a simple backwater or eddy in the great stream of evolution. So far, then, we have found no line of development which may lead us on to the summit of the vegetable kingdom; and the second group of the *Pteridophyta*, the *Equisetineæ*, to wit, will not help us, since this peculiar and intensely characteristic shoot, which attained its greatest developments in Carboniferous times, and of which the present representatives are a miserable remnant, is also entirely out of the direct main line of progress and lands us in another blind alley. We may just note in passing that there is reason to think that this group also was derived from the *Hepaticæ*.

We now turn to the last group of the Pteridophyta—the *Lycopodineæ*—and here (neglecting those peculiar plants *Tmesipteris* and *Psilotum*, which, however, can scarcely be other than blind alleys again) we have a pretty clear line of evolution from *Phylloglossum*—in the root of which Mr. Vaizy has found similarities to the foot of mosses—through *Lycopodium* and *Selaginella* (the "Lycopodium" of our greenhouses) to the *Coniferæ*, which, as we have usually been taught, lead on through *Gnetaceæ* to the flowering plants. Here at last we might think that we had a line of progress digressing into none but minor blind alleys at any rate; but Dr. Campbell[1] again steps in and suggests that the flowering plants have arisen, not from *Coniferæ* but from *Isœtes*. This is to remove from *Isœtes* (whatever the fate of *Cycadeæ*) the reproach of leading into a blind alley, but at the expense of relegating the great Coniferine line of development to a termination in another blind alley.

Here then we may stop. Without doubt a multitude of smaller blind alleys might be found diverging for short distances from various points were we to indulge in a detailed investigation of the Conifers and of the several families of

[1] Botanical Gazette, Vol. xvi.

Angiosperms; but it is unnecessary here to enter into such details. Our purpose is sufficiently served by pointing out that, throughout the evolution of plants, so far from there having been any innate tendency to continuous progress, we find that in the vast majority of cases the various lines of ascent, along which the evolving species traveled, ended abruptly in blind alleys, and that along one line only has the highest evolution been reached; while the collateral lines have reached various and successively lower levels. It is particularly instructive that, among both the lower kingdoms of Thallophyta and Bryophyta, the prize did not fall to the respectively highest forms; for, whether we look at the *Fungi*, with their various stages finally leading to no really high forms at all; or to the *Algæ*, in which the two lines of evolution ended respectively in the *Fucaceæ* and the highly differentiated *Floridæ;* or to the Bryophyta, in which the also highly differentiated Mosses ended blindly; we find alike that, so far as we can see, the higher a group has progressed, the heavier are the odds against its doing much farther good for itself; for the best chance of begetting the direct line of ascent lies with the lower forms.

The Florids and the Mosses are both very highly organized and specialized forms, possessing many analogies with the Vascular Plants; but the line of ascent to the latter rises through neither Florids nor through Mosses, but through the lowlier green *Algæ* and Liverworts. In the Pteridophyta only do we find the higher forms in each of two lines of development, *viz.*, *Selaginella* and *Isœtes*, giving rise to the higher group of the Flowering Plants; and be it noted that, even on this latest theory of the genealogy, *Selaginella* ends finally in the great Coniferine blind alley, whilst there is much reason to think that the Cycads too, although perhaps equally with the Angiosperms, springing from *Isœtes*, are only another blind alley; and of course the third Pteridophytic line of the *Equisetineæ* has—whatever its potentialities for farther development may have been; and these, in so specialized and peculiar a group, were perhaps hardly very great—become practically almost extinct.

XUM

One qualification need, in conclusion, only be referred to. The foregoing remarks are based upon data that are at present admittedly only provisional, and in a large measure hypothetical. But the mere fact that such theories are tenable, and are provisionally accepted, more than suffices to justify the warning that it has been our object to deduce, against attributing to vegetable species the Nægelian innate tendency to progress. Whatever modifications may ultimately be found imperative in the theories of the authors from whom we have quoted, we may safely assume that they will *not* lie in the direction of giving a more linear form to the genealogical scheme, nor of diminishing the number and importance of the blind alleys; for the whole tendency of modern research lies in the opposite direction.

It is true that a Nægelian might retort, that in the very number of these blind alleys he saw the best proof of the impatient striving after progress, and of the innate tendency to develop into higher forms, but to reconcile herewith the blind alley termination of such forms as *Florideæ*, *Musci*, *Cycads* and perhaps *Conifers* would, as it seems to us, entail very important modifications of the theory of an innate tendency to progress. Accepting that theory, we should have a right to expect that however many collateral lines of development were to be found, each of them should at least have ended in something approximately as high as *Angiosperms* or, at any rate, *Gymnosperms*. But regarding the evolution of either higher or lower forms as an adaptation to the environment, and recognizing also that the more highly specialized and more highly developed becomes a form, the heavier are the odds against its further development, we can easily understand, not only that the Floridean and Muscinean lines of development terminated blindly in forms that were suited to their environment, but also that, in the evolution of the main line of ascent, the point of departure has so often been from the more mobile and less specialized lowlier forms, such as *Coleochaete* and *Anthoceros*.

"MENTAL TELEGRAPHY."

By Claude Stuart Coles.

"Mark Twain's" article on "Mental Telegraphy" will probably call the attention of a large number of readers to a hitherto unconsidered subject. Certainly there is within us an undeveloped sense. What it will be in its entirety rests with the future, but with us lies the wonder of discovery and of development.

There is nothing supernatural or unnatural about this power, it is only considered so by the unthinking. We all know what our ancestors thought of Franklin when he experimented with a key. Compare the feeling of that day with the matter-of-course way in which we take each new invention for the use of our partially understood servant, electricity. There is no more electricity to-day than there was in the dark ages. We have learned to use it, that is all.

Within us is a power, sleeping. Once in awhile some sensitive soul has felt it stir, but there was no known law that governed it, no logic with which to convince others of its being; so it was buried deep in the inner consciousness, where hide ideas that dare not seek light because they are in advance of their age.

Not so now, as "Mark Twain" says. This is the age of new ideas, and everywhere people are thinking on this subject and seeking the unknown law that governs this power. That there is a law, no one who has observed can doubt; but to find it, and control this power when developed, is the question before us.

That every one should have this power latent, many doubt. Every one is not a musician, neither is every one an artist; but for those to whom it is given, life takes on new beauty and duty becomes sweet. What matter how sordid our surroundings, we can rise above them. What matter how irksome the task, we can grace it as we will. Time and

space and absence mean naught, when this power is understood. Many have told me of experiences in this line; but in the telling one is always surest of one's own.

Long ago, at the house of a friend, I saw a photograph of a man's head. As I picked it up there came over me a sense of having known the original, it was the face of a "friend!" When my hostess entered I asked about the photograph, and she told me who it was. The name meant nothing to me, but the face meant all things that I knew. Several times in the next week I looked at the photograph, always with the same sense of "having known." Then eight years elapsed, during which no memory of that face came to me. One day at the theatre there flashed over me that same curious sense of "having known." Instinctively I turned and caught full the glance of the original of the photograph. What he was doing there I have never found out.

Several miles away from me lived a friend. Days would elapse without our meeting, but if I sat down and wrote her a note she would come, always crossing the note. I became so certain about it after awhile that I would write the note and tear it up. The thought would stir in her the desire to see me. There was no use in mailing it.

The sight of a certain handwriting would always make my heart sink, it was something that I could not reason myself out of, yet the letters were pleasant and the words fair. One dark day I found out that my instinct was right. I trust it now.

Often, like Mark Twain, I have taken a letter in my hand and told its contents and described the sender in looks and character, though the letter was from one of whom I knew nothing.

Many times I have tried with no success whatever. Now why should this be? What is the secret of this power? How can it be controlled?

Across one's brain flashes the thought of a friend. Is that friend's consciousness of one the cause of the thought in one's brain? Or is the thought simultaneous and the

result of a sympathy called into being by some combination of earth, and sky, and sea?

"Merely coincidence," says the thoughtless; but one who observes sees a certain sequence in the coincidence. The field is wide, who will open it to others?

"But it is not logical," objects the skeptic. To the child who does not understand decimals there is small logic in the rule of three; and in this matter, is it not, we are but just grasping the rules of addition!

THE DOGMATISM OF SCIENCE.

By Mrs. Bloomfield Moore.

Henry Thomas Buckle, in a paper read at the weekly evening meeting of the Royal Institution of Great Britain, Friday, March 19th, 1858, said that "an exclusive employment of the inductive philosophy was contracting the minds of physical inquirers and gradually shutting out speculations respecting causes and entities; limiting the student to questions of distribution, and forbidding to him questions of origin; making everything hang on two sets of laws, namely, those of co-existence and of sequence; and declaring beforehand how far future knowledge can carry us. But," added this great man, "we shall not always be satisfied with seeing the laws of nature rest on this empirical basis; and the most advanced thinkers are looking to a period when we shall deal with problems of a much higher kind than any yet solved; when we shall incorporate mind and matter into a single study; when we shall seek to raise the veil and penetrate into the secret of things."

No man nor woman of intelligence, who is conversant with the writings of "the most advanced thinkers" of our age, can fail to see that this time is near at hand; and yet dogmatic science refuses to put itself in a position where it could announce that the veil is already raised, and, to quote the words of Prof. Lascelles-Scott[1], that "the door which

[1] Physicist at the Government Physical and Chemical Laboratories, Forest Gate, Essex.

prejudice has declared to be shut and bolted is even now ajar, and gleams of light are struggling over the threshold from Keely's discoveries."

Of course, new hypotheses should not meet with too ready an acceptance, and the professor, with admirable caution, takes the text of his review of "Keely and His Discoveries," from the Syracuse philosopher—Epicharnus—"The very nerves and sinews of knowledge consist in believing nothing rashly." But with such evidence as he sets before his readers (in the October number of THE NEW SCIENCE REVIEW), the determined blindness of dogmatic science should not be permitted to delay, to another century, the general promulgation of truths which have been already established by the testimony of some of the most distinguished American men of science of this age. The fact that there are, as yet, no commercial profits from Keely's discoveries is all that retards the promulgation of these truths; but the law allows no patents on new truths nor on a principle of nature. Until the vibratory circuit, operated by this costless current of force drawn direct from space, is connected with some patentable device, Keely's discovery has no more commercial value than Newton's discovery of gravity. Therefore, as science still denies the fundamental doctrines on which this new system of physics is based, the only hope lies in the prolongation of Keely's life until commerce, instead of science, is able to make the announcement; unless the press, with its gigantic power, lends itself to the efforts now being made to bring before the public the present position of Keely in his great work of evolution. Of another discoverer of unknown truths the poet Cowley wrote:

"Bacon, like Moses, led us forth at last;
The barren wilderness he passed;
Did on the very border stand
Of the blest, promised land;
And from the mountain's top of his exalted wit,
Saw it himself, and showed us it.
But life did never to one man allow
Time to discover worlds and conquer too."

Scientific caution is necessary at all times, and more especially so with discoveries which antagonize the established order of what is supposed to be scientific truth. But of quite a different nature is that stolid and contemptuous indifference manifested by those "lights of science," who consider it derogatory to their dignity to interest themselves in an examination of claims that, if proved to be true, would revolutionize the accepted dogmas of science. When Italy was disturbed by Galileo's discovery, the same thing occurred. It was a professor of the University at Padua who refused Galileo's invitation to look through his telescope and obtain proof of his assertion that "the world moves."

The world of thought moves faster than in the days of Galileo. Under the pressure of outside opinion and the gradual infiltration of new truths, men of science will, in the end, be awakened into honest and serious attention to Keely's claims. New truths pass more quickly, now than formerly, through stages of blind, unreasoning opposition. This improvement does not spring out of any change in human nature in scientific men, for their "good-fellowship," among themselves, is never extended beyond those researchers who maintain orthodox views and support each other in their claims.

The hope of Keely's life being prolonged "to conquer too" (nearly three score years and ten as he is now), would be much more likely to be realized if the certainties of the scientific value of his discoveries were made known more widely, together with the *uncertainties* of his living to complete all that is necessary before there can be any financial gain therein.

Notwithstanding the persistent denial of physicists, who have not examined into Keely's claims, the advancing wave of interest in his work cannot be kept back, for it will be sustained in its course by the ever-increasing pressure of a larger outside public of intelligent and interested minds, not wedded by long association of thought to special systems, and having no motives of self-preservation prompting them to repel what appeals to their intellectual capacity of

comprehension with much greater force than to minds educated on rigid lines of thought, as is the mind of the physicist. Such minds, says Hovenden, from the necessities of the case, are the least capable of solving a problem which can only be solved by views that are foreign to the fundamental ideas in which the physicist has been educated.

The distinguished men of science, Profs. Leidy, Brinton and Koenig, who investigated Keely's work in 1889–90, testing the current of force produced with the most sensitive galvanometer of the University of Pennsylvania, publicly asserted that it was free of electricity, magnetism or any known force—scoffing at the less than school-boy knowledge, which had, in 1876, pronounced it to be compressed air.

Ricarde-Seaver, an European electrician, who, after investigating, returned to London and gave testimony in favor of the discoverer, was asked to withdraw his name, when the balloting was about to take place for membership at the Athenæum Club, by the very man of science[1] who had proposed him sixteen years before, the only reason given being his espousal of Keely's claims as a discoverer.

Such an experience (and more notably the recent experience of Prof. Oliver J. Lodge) proves that the founder of new systems must look to the power of the press, which is greater than that of the sword, when help is needed in making known to the world the importance of newly-discovered truths not accepted in general by those whose canons they controvert.

One of the most widely-known English physicists,[2] who for more than ten years has followed Keely's progress in his experimental researches, when asked in 1891 why he was not willing to make public his views of their nature, replied: "If I am called before a bar of justice to give testimony, I am cross-questioned by judge and counsel. It is the same at the bar of science. I cannot say what I think. I must say what I know, what I believe, what I have seen."

[1] Lord Kelvin.

[2] Prof. Dewar, of The Royal Institution of Great Britain.

As long as the so-called "Lights of Science" hold the attitude that they take toward lesser lights, who are interested in Keely's work, no physicists of note can be expected to interest themselves in Keely's claims publicly.

Prof. Lodge, in closing a recent article, "Unusual Physical Phenomena," writes: "And now, finally, let me disclaim all missionary spirit in this long exposition. The business of a scientific man is the pursuit of natural knowledge and the imparting of such portion of it as has by long trial become recognized and orthodox—*i. e.*, such portion as people are willing to receive. For I need hardly remind the reader that at one time the science of nature, or physics itself, was very far from being orthodox, and that in past days promulgators of any new truth had to pass, not through the fire of a little friendly badinage and ridicule, but through fire of a much fiercer and more searching character; unless, indeed, they recanted their 'errors.' Instruction in orthodox branches of science is now permitted to youth; an unorthodox department of knowledge may have to wait many years before instruction in it can be willingly received, even by adult and experienced minds. Let it wait! The instinct of an investigator and teacher is to set forth, as best he may, such natural truth as he is able to perceive—such truth as the interworking of his era and his opportunities have revealed to him—and there he must leave it. For its reception by the human race, he is not responsible.

"The universe is not so simple a matter as men in this century have been apt to think. *All we ask for on the part of our contemporaries is an attitude of mind willing to give to new truths a chance of life. If it be of God, they cannot indeed ultimately overthrow it; but they may, by determined blindness, seriously delay its coming, and entirely prevent its reception in their own age.*

"I ask for no hasty belief. No one can usefully believe things of which he has had no experience. He may say that the statements of those who support them are or are not entitled to respect, and that, if he were forced by a pistol at his head to take sides prematurely, he would range himself

on one side or the other; but till he has had some sort of first-hand experience his belief and his disbelief are equally worthless, except in so far as they may lead him to devote some portion of his time to a study of what has been recorded on the subject, and to an unprejudiced, critical contemplation of whatever phenomena may in the progress of events unfold themselves before him."

The public is now asked in the same spirit to give attention to Keely's present position in an unorthodox department of true scientific research. The long course of experiments made by English and Continental physicists in the case of the medium Eusebia, seems to have proved nothing more than that obsession did not cease with the days of the Apostles. In fact, Mr. Keely is opposed to these mediumistic experiments with subjects possessing abnormal will power. Hypnotism, animal magnetism, suggestion, etc., he considers are so little understood in their workings, that it is like an obstruction placed on a railway track: the engine may dash it aside, or it may wreck the train. The experimental researching of Keely, in manifestations of will power, is of an entirely safe nature, made with dynamic apparatus instead of on the human brain and the physical organism.

Since the insults to which he was subjected several years ago by a professor of physics who visited his work-shop, Mr. Keely has refused to make explanations of the operations of his instruments to those physicists who have reluctantly condescended to inspect his aerial navigation machinery, preferring to wait until the propellor is able to speak for itself. At present, however, for certain business reasons, it has become necessary for him to explain the operation of the machine, and Dr. Tuttle, physicist at the U. S. Mint in Philadelphia, has been chosen to receive this instruction. The series of experiments which Mr. Keely was preparing to give (as set down on page 464 of the April number of THE NEW SCIENCE REVIEW) before an expert committee, will therefore be made before Dr. Tuttle; but no public announcement will follow on account of the business complications alluded to.

It has become evident that an authoritative public announcement of the completion of Keely's long work of evolution, in a machine adapted to navigation of the air, would facilitate stock jobbing operations. That such undesirable results may be avoided, this statement must be delayed until Mr. Keely's plan of reorganization of the old Keely Motor Company has been accepted by the shareholders of its stock, and a settlement made with them, as set down in his circular No. 1. (The circular will be found in the advertisement pages of this number of THE NEW SCIENCE REVIEW). When Mr. Keely has effected this settlement and completed his railway traction engine, then, and not before, will the stock of the Keely Motor Company possess marketable value. The expert American electricians and engineers, who were to have formed the committee of investigation, prefer to wait until this is accomplished, lest their names be used to facilitate Wall street operations in Keely Motor stock.

Mr. C. W. Baker, of *Engineering News*, upon withdrawal of the invitation that had been extended to him (in accordance with an intimation from him that he would like to pursue the subject farther than he had been able to do), expressed his regret that the plans formed for giving a wide publicity to the result of the demonstrations had been frustrated from want of coöperation on the part of the Board of Directors of the Keely Motor Company. Nikola Tesla, for reasons that need not be explained, would not have been able to serve on the committee. It is well known that he is striving to draw power from space by purely scientific methods, which Keely succeeded in doing in 1893 by "unscientific methods." An earnest effort has been put forth to induce this distinguished man of genius to acquaint himself with Keely's system of aerial navigation, in order that he may more quickly attain one of the goals he is aiming to reach—that of producing light devoid of heat.

It is now a number of years since Mr. Tesla crossed the border line of the circle in which all other electricians are working, on their treadmill round, but he still remains in the interatomic field of research, apparently unmindful of

the triple conditions that govern electricity in the relation which it sustains, in that field, to the first order of the luminous.

Tesla's great penetration may enable him eventually to attain his aims on orthodox lines of research; but, in the writer's opinion, were he to acquaint himself with Keely's system of resonance, it would be but a short time before he could induce electrical alternation of such an intense degree as to produce a light as susceptible to the retina as is solar light. Even should Tesla succeed in drawing power from space, on his own line of research, his position would still be remote from all the conditions governing magnetic and electric phenomena in the sympathetic field, where Keely has solved the problem of navigation of the air. Keely calls this realm the interetheric or celestial, in contradistinction to the terrestrial or interatomic realm, which Tesla is researching. The terrestrial sympathetic forces are subservient to the celestial sympathetic. Tesla stands as it were on the bridge which connects the primary two-thirds of the electric stream—the subdominant current with the dominant. Even should he hook on to the dominant, he would still be subserved to the terrestrial neutral; far in the rear of sympathetic union to radiating celestial outreach,[1] the connecting link of which exists in the interluminous, and remote from all the conditions that govern electricity sympathetically. Therefore Tesla is wrong when he says that "electric phenomena and ether phenomena are identical;" nor will he arrive at a true conclusion, as to the relation or association of the two, until he has brought about an alter-

[1] The sympathetic outreach of negative attraction is born of the celestial and impregnates every mass that floats in space, seeking out all magnetic or electric conditions. All these masses are subservient to celestial outreach. It is the power that holds the planetary masses in their orbital ranges of oscillatory action. Magnetism is static. Sympathetic negative attraction reaches from planet to planet, but electricity does not, nor does magnetism.

All the magnets in the world could not induce rotation, no matter how differentiated, but polar negative attraction induces rotation, as exemplified scores of times in an insulated compass-needle before the professors of the Pennsylvania University in 1890. (See page 279, "Keely and his Discoveries." The Transatlantic Publishing Company, 63 Fifth avenue, New York.)

nation of that intensity which induces light visible to the eye. Even then he will not have reached the compound interetheric—the border line to the introductory luminous.

It is evident that Tesla already comprehends the law governing transmission and dissociation in electrical alternation with regard to its reception by the physical organism, whereby an increase of the number of volts that prove fatal to life are harmless, and given without any risk to the subject. The ear is not susceptible to the vibrations of inaudible sounds; nor the eye to those of light beyond the number necessary for sight. A wheel having five spokes and making ten revolutions per minute gives fifty alternations on the spokes, which are readily counted by the eye; whereas an increase in the revolutions, to five hundred in ten minutes, increases the alternations of the spokes beyond the power of the retina to receive and count.

It is the same with electrical alternation in regard to its receptiveness by the physical organism. Phenomenal as it may seem to those ignorant of the fact, this is a standard truth in sympathetic physics, which Tesla's penetration did not fail to discover. The plane of research that he occupies in regard to electrical phenomena, is as much above that of his fellow electricians as is the plane occupied by Keely (in researching the problem of aerial navigation) beyond the realm in which those inventors are working, who are constructing balloons and flying machines on various principles, while still ignorant of a force in nature that is antagonistic to gravity and overcomes it; thus making navigation of the air, with ships of thousands of tons burthen, both possible and perfectly safe.

Electricians will no longer remain captive in their domain when Keely's system is published to the world; as it will be when he has effected the settlement that he seeks. If this settlement is not effected, without the delay of litigation, his secrets will die with him, in all probability, for no one but himself knows the process by which dead metal is sensitized so as to be operated upon, as the brain is operated upon by celestial radiation.

XUM

Were Tesla and Edison brought to a proper appreciation of Keely's methods, were they to make themselves acquainted with his system of sympathetic physics, what might not be expected of them in view of their brilliant achievements on a lower plane of research? The march of science would then be a triumphal one indeed.

Let Keely be known to Tesla and Edison as the "great discoverer" which Professor Koenig called him in 1891, and the press will then be ready to publish what has already been accomplished for science. This can be done without affecting the stock market, as long as there is no engine to base speculation upon. Why should science wait upon commerce? Is it not enough that "the whole world problem" is solved by this new system of physics, demonstrating, as it does by dynamic apparatus, the truth of Professor Ladd's words in his recent work, "Body and Mind," when he says, "The Being of the world, of which all particular beings are parts, must be so conceived of as that in it can be found the One Ground of all interrelated existencies and activities."

The cosmical law of sympathetic association, as set down in Keely's system of Vibratory Spiritual Physics, has solved this greatest of all problems—both psychical and physical—the problem of the human will.

Shall this system, founded upon knowledge known to the ancients, which has been lost out of the world for centuries, only be regained to be lost to this age because of the dogmatism of science? There is a warning in Cowley's words, which men of science will do well to heed:

> "But life did never to one man allow
> Time to discover and to conquer too."

HAS MENTAL HEALING ANY SCIENTIFIC BASIS?

By Henry Wood.

Doubtless there are very few thoughtful persons in whose minds something like the following questions have not been suggested: What about the growing interest in curative mental forces? Have such theories any scientific basis, or are they composed in various parts of imagination, mysticism and charlatanism? Is there any underlying orderly law, that may be hidden, at the foundation of the numerous claims in this direction which are being made?

The average man would like to get at the plain unvarnished facts. He desires to find the truth, both for its own sake and for its possible uses. If there is even a modicum of virtue in the systematic application of thought-energy, either in behalf of another or in self-application for the prevention and amelioration of human woes and ills, the world seriously needs such a reinforcement, and every lover of his kind would welcome it. If, on the other hand, it has no basis of truth, its hollowness should be exposed.

An honest and impartial search for truth for its intrinsic value, in any department, is rarely unprofitable. Many of the scientific treasures that have been unearthed in the past, which have greatly enriched human accomplishment, have been found in unexpected, and even familiar places, where multitudes had almost stumbled over them. This has been true in physical, as well as in social, political and ethical science. When new truth—new only to human appreciation—has been finally interpreted and introduced, every one has wondered that a thing so obviously simple had been so long delayed. The apparent slowness, therefore, was not on account of any complexity, but because of general unreadiness. The channel which it finally filled had been otherwise occupied.

XUM

But truth is, and ever will be, restless until recognized. Each special truth is needed to fill a fitting niche in the greater unit, and there is discrepancy and incompleteness until it finds its place. When Kepler discovered the law which regulates and adjusts planetary revolutions, it was found to be the keystone of an arch of indefinite strength and extent.

A word regarding the writer's standpoint may not be inappropriate. It is often taken for granted that one who presents any theory or principle, naturally has some professional or pecuniary interest in it, and that he is therefore its advocate. This is especially so when the departure is in a degree unconventional. If not prompted by such motives, it must be a "hobby." Why should not such an one drop into the smooth current of common thought and drift along, and refrain from any overt attempt to obstruct or divert it?

A personal experience a few years since of unusual depth and intensity, involving an application of the new philosophy, was the starting point of a most thorough, impartial and conservative investigation, which has followed. An intense philosophical desire to probe as deeply as possible, without fear or favor, was awakened. With such a vivid, subjective demonstration of the power of a law not yet generally recognized, no one possessing any altruistic spirit could quietly settle down to silence, simply because his *own* personal needs had been satisfied.

Is there a great principle, capable of wide application, that has been so near that we looked right through and beyond it? Are there orderly forces in the realm of mind, the utilization of which would be more important to humanity than those recently harnessed in the electrical domain? Are there subtle thought-powers that are willing servitors, waiting for our nod of recognition?

Admitting that much empiricism, some charlatanism, extravagance and a spice of disorderly logic have swathed themselves around this new development, it is clearly in the line of legitimate philosophical inquiry, as well as humanitarianism, to find through impartial research if it have laws

which are capable of exact definition. Such a conservative investigation, continued for several years, non-professional and unbiased, involving not only an examination of its literature and philosophy, but also the collection of data, embracing hundreds of varying demonstrations, have convinced the writer that here is a great realm of truth which contains the elements of an exact science. We have yet hardly arrived at the threshold of an intelligent understanding of the principles of mental dynamics. We are ever ready to study political, social, moral and other objective economies exhaustively, but strangely omit one which is nearest and most vital.

At the present moment, mental or psycho therapeutics is almost past that stage of flippant criticism, misapprehension and prejudice, through which all new advances have to make their way. This testing, through adverse criticism, and even ridicule, is not altogether to be deplored, nor is it without real use. It renders a needed service in sweeping off excrescences and extravagances which always attach themselves to new developments. Only by such fusing can that which is real be purified of its dross. The residuum of truth has inherent vitality. Fires cannot burn it nor waters quench its living energy. The struggle through which it passes in winning its final standing ground is also educational, both to its assailants and defenders.

Theological, social, economic and ethical dogmatisms become gradually softened toward innovators, and finally coalesce, or at least make terms with them, and the therapeutic and materialistic dogmatisms which have come down to us from the past will form no exception to the rule. Nothing is bad. One of the most suggestive teachings of synthetic evolution is, that everything has a use in its place and time. Each system forms a terrace or platform from which men may reach higher.

But turning to a more specific study, it is evident that only a hasty glance at fundamentals is practicable within the limits of a magazine article.

XUM

There are three different sides through which the central arcana of the new philosophy of life may be approached, which, in a general way, may be defined as the rational or scientific, the occult or mystical, and the religious or spiritual. When understood, these are only varying aspects of one unit. They are the views that are responsive to the unlike standpoints of different observers.

The final recognition of the divinity in man, or the essential spirituality of the ego, is the great truth which forms the apex of this new and vital philosophy. Man, though having outward and material expression, is, in his real being, an immaterial entity. This great truth which involves his inmost and essential divinity is the high, though possible, quality of consciousness which it is his privilege to cultivate. But a tower must be erected before its capstone can be laid; so the approach to the transcendent summit of spiritual evolution must generally be made through other, and lower, though not unimportant approaches.

While there are some who are qualified and in readiness to take in directly the highest phase of truth, the great majority are only appealed to by its rational or scientific aspects. There is also a contingent to whom, from temperamental quality, the occult or mystical side of mental manifestations is very attractive, but they compose only another small minority. Recognizing that the great majority of all who have not yet crossed the threshold of the new thought will be more interested in its rational and philosophical side, in this brief survey attention will be almost wholly confined to that line of approach.

All true science is founded upon a recognition of law. If law were variable, there could be no science. This basic truth has long been admitted in its application to the physical realm in all its departments. The visible action of one natural law may be overcome or neutralized by another which is superior, but neither is ever suspended. Not until quite recently has the reign of law been recognized in the mental and spiritual economy. A few years since, when Professor Drummond published his "Natural Law in the

Spiritual World," there was a wide commotion. Both theologians and scientists regarded the spiritual domain as beyond the pale of law, and this view is yet quite common. Everything there was capricious, in obedience to the fiat of a changeable Deity. Events, manifestations and "providences" were "special," which, scientifically interpreted, means, without order.

But the best thought of the world now recognizes no domain as lawless. Cause and effect are inseparably linked together. But this does not in the least imply fatalism. Man being a free moral agent, or a kind of secondary creator, learns to comply intelligently with law, and thereby wield its power. Instead of binding him, it becomes his great lever by the aid of which he may move all things.

The laws of mind and spirit being as exact as those of matter, it follows that, to the degree they are correctly interpreted, they can be utilized. The powers of thought, and the uses of the imagining faculty, have been inadvertently squandered or misapplied. Their great energy has been abundantly expended, but positive accomplishment has been impossible because their forces have pulled in opposite directions. Thoughts, emotions, fears and hopes have their qualitative sequences, as truly as active screws and pulleys in mechanics. But to accomplish results they must be systematically turned in the right direction.

The basic law which forms the mainspring of mental healing energy is that all primary causation, in its last analysis, is located in mind. If this once be conceded, its beneficial employment through idealism is distinctly logical. The innate tendency for ruling and concentrated ideals is always toward outward, or physical, qualitative expression.

Exact definitions are indispensable. Just what is man as an entity? Is he the life, mind and soul, which thinks, reasons and aspires, or is he the visible body? Is he soul having a body, or body having a soul? He must *be* one, and possess the other. If mind be only a quality, property or dependent of organized matter, it is obvious that it cannot outlast its base and sustainer. If, therefore, materialism—

so generally though unconsciously held—be true, man cannot survive that event called death. There is no other alternative. If the reality, or the ego, of man be clay he must perish. Nearly all will deny any such theory, but the vast majority unwittingly feel and live it. When they say "I" they think of the visible form. Conventional modes of expression show the trend of thought. "I am cold," "I am ill," "I have hurt *myself*," are a few of numerous possible examples. Such a state of consciousness binds men to the material plane, and imposes its numerous limitations. Prevailing philosophical, scientific, therapeutic, sociological and theological systems are not ostensibly upon such a basis, but a subtle materialism has permeated them. They mainly recognize lower law, which, though exact within its own limits, can and should be regulated by that which is higher in rank and quality. Men live mainly in bodily sensation, which is only a false sense of life—that which we have in common with the animals. Real life is a soul-sensation of principles and ideals.

Man has mistaken his instrument—the body—for his master. He has become a vassal in his own legitimate kingdom. This inversion which he has imposed upon himself by weakly yielding consent and acceptance is the real source of his ills and inharmonies. He outpictures his own estimate of himself. This accords with the law of expression, which is always from within outward, from the immaterial toward the material. As thought is the great moulding force, reformation must begin at the centre. His opinions concerning his own being are incomparably of greater importance than those relating to things outside, but yet nearly all of his researches are objective.

Man is a soul which, through an inherent tendency toward articulate manifestation, has picked up a little plastic material and erected it into an animated statue. This same dust has been, and will be, used over and over again to express other and different grades and qualities of life, and therefore it can have no distinctive character or identity of its own. It is clay in the hands of the potter. Shall man rule it or be

ruled by it? Manifestly the latter so long as he fails to assert his supremacy. But he needs reinforcement from within rather than external patching. If he would make his instrument serve him, his nerveless grasp upon it must be tightened. If he fails in its control it is only due to his weak power of command. Through his mistaken and materialized subjective consciousness it has actually turned upon him and played the tyrant. Though it has no power, *per se*, he has clothed it with energy, and then tried to treat with its imperious demands. It is normal that the higher should rule the lower. Is the instrument above him who wields it? This is contrary to the established order, which in its very nature is beneficent.

Space will only permit of the briefest mention of a few of the numberless proofs and illustrations of the working of subjective mental forces. But first it is necessary to note the radical distinction between causes and occasions. The former are always back of, or beneath the surface of, manifestation. One says that "a draft has caused a cold." But this is incorrect. The draft was the occasion, and susceptibility the cause. A dozen persons are equally exposed to a contagion or a malaria. Only half of them "take it." Subjective conditions made the wide difference between opposite results. Occasions are located without, causes within. But people will circumnavigate the globe in the effort to remedy such occasions as climate, air, temperature and humidity, without giving a thought to underlying causes. Ordinary occasions are harmless unless accepted, feared, and believed in as causes. These mental conditions confer a false and gratuitous causal power upon them.

But it will be asked, "Can one sit in a draft with impunity, if he then and there resolve not to take cold?" Most positively, no. As well ask if a plant which requires the sunshine and moisture of a whole season can grow in an hour. Temporary surface thinking, though good if in the right direction, can hardly transform one to a perceptible degree. Radical invigoration can come only from a sustained and focalized attitude of mind which is attainable

through the firm holding of positive ideals. The present mental status is a composite of the whole past, and can only be changed by degrees.

A few concrete illustrations of the law of mental causation may now be noted, but it is not easy to make selections out of a multitude of phenomena, which are available and admitted. Facts are conceded, but the underlying law which produces them has generally been unrecognized, and has therefore remained unutilized. The time for recasting had not come, and diagnosis was in accord with preconceived theories.

Beginning with barbarous tribes and with pure superstitions, well authenticated results show the power of simple suggestion and expectation. The healing charms and incantations among aborigines have admitted potency. With all their barbarism they are near to nature, and keen in detecting causative roots. Among many nations and religions, images, ceremonies, holy relics and shrines are known and admitted to have wonderful therapeutic power. They divert the mind from the ailment, and stimulate a strong faith which arouses recuperative forces to action. If baseless superstitions can be so efficacious, what is not possible from an intelligent and systematic employment of scientific idealism?

Negatively, mental causation is abundantly proved by its action in the direction of harm. Ignorance and fateful acquiescence have inverted this great power, which is good in itself, and it has thereby been rendered disastrous in its working. Every one is aware of the disorderly effects of fear, anger, envy, guilt and anxiety, in pulling down the physical organism. Acute fear will paralyze nerve-centers, and sometimes turn the hair white in a few hours. A mother's milk may be poisoned by a fit of anger. An eminent authority, Dr. Tuke, enumerates as among the direct products of fear, insanity, idiocy, paralysis, profuse perspiration, cholerina, jaundice, sudden decay of the teeth, fatal anæmia, skin diseases, erysipelas, eczema. Passion, sinful thought, avarice, envy, jealousy and selfishness, all press for

external outpicturing. Even false philosophies, dogmas, and especially false concepts of the Deity, weaken and interrupt bodily vigor. But a conscious fear of any particular disease is not needed to induce it. The general and unconscious fears and acceptances of generations have been shot through the warp and woof of our mentality, and we find ourselves on the plane with disorder. Our door is open to receive it. But what is it? As a condition it is existent, but not as a God-created entity, in and of itself. Our sensuous beliefs have galvanized it into life. Disease is a negative; the lack of ease. Mental states physically mirror themselves to sense-perception, but as the process is gradual and complex, we do not readily follow the link between cause and effect.

Those unique experiences known as "stigmatization" furnish remarkable evidence of the power of mental suggestion. The term, as most persons are aware, refers to marks, or apparent tattoos, branded upon the body, corresponding to the wounds believed to have been inflicted upon Jesus at the crucifixion. A crucifix held before the eyes and adored, kissed and concentrated upon by sensitive and highly wrought natures, tended powerfully toward physical outpicturing as a natural result. Such phenomena were regarded as "supernatural," and that was held to be a sufficient explanation. Though the suffering was often intense, they were regarded as special tokens of Divine favor. Beginning with St. Francis of Assisi (A. D. 1224) and coming down to the present time, there are about ninety well-authenticated cases on record, of which eighteen were males, and seventy-two females. The "*stigmata*" appeared in the hands, feet and side, in spots or circles, most often of blackish-gray or rose-color. In some instances, the scars, and even bleeding, would occur on Good Friday and disappear on, or soon after, Easter Sunday. Space will not permit of detail, though much which is historically confirmed beyond all question is richly suggestive. *Stigmata* which have occurred during the last two centuries are minutely recorded in medical annals. They have been merely classed as remarkable or abnormal, and thus dismissed. Prevailing

materialistic notions delayed the employment of such herculean psychic forces in an opposite and beneficent direction.

A limited and unconscious employment of the law of mental causation has appeared in occasional outcroppings of "miraculous healing" all through the ages, at various shrines and holy places, and from contact with sacred relics. At the present time notable cures are constantly taking place at Lourdes, Treves, Rome and many other places, which are well-known and admitted by all who have given them careful investigation. Phenomena of this kind might be adduced at any length. The facts are conceded. It is only the *modus operandi* that has been unwittingly mystified.

But now physical science itself is furnishing additional confirmation. Experiments in the laboratories of psychophysicists—notably those of Prof. Elmer Gates of the Governmental department of this line of scientific research at Washington—chemically demonstrate this philosophy. The most sensitive tests and analyses show that distinct corresponding products appear with unwavering certainty in the physical organism as a sequence to specific mental conditions. Of those which are inharmonious or bad, each produces a distinct poisonous element in the bodily economy. On the other hand, good, harmonious and spiritual thinking fruits in products that are vitally helpful and nourishing. These are detected and severally recognized in the perspiration, secretions and circulation of the individual. About forty of the good and as many of the harmful have been identified.

But if mental forces be admittedly potent, how can they be made practically available? To answer this question thoroughly would require a volume, so that only a few hints can here be given. But when any general law is discovered, and admitted, a great end is gained, for the ways and means of its application are increasingly obvious and easy. This has always been the case in physical science, and is notably illustrated in the recent development of electricity. To harness a force after its working methods have been divined is not usually difficult.

There are two different lines of treatment for mental invigoration, though they may be employed together. The first includes what one individual can do for another, and the second a self-application of the same principle. In a brief study of the first—the influence of mind upon mind—proofs that mind *can* influence mind will not here be elaborated. Thousands of psychological experiments and experiences prove it, and every recorded case of mental healing attests it. None of the workings of physical science are better confirmed than the truth of telepathy.

A mind may be compared to a resonant instrument with innumerable strings of the most delicate quality. Systematic and concentrated thought goes out in vibrations, and corresponding chords in another mind respond. Each thinker is a battery of positive forces which may be directed. Thought-energy is no less normal or reasonable than other unseen energies that are transmitted through the ether, such as attraction, repulsion, cohesion, magnetism and electricity. But how is telepathy or thought transferrence to be utilized? Obviously a physical body can only be reached through the mind of its owner. But if that can be modified through the influence of another's mind, practical results may be secured. As soon as the law is understood, every strange or marvelous aspect is eliminated.

Certain persons of highly trained and concentrative power can gradually induce a new quality of consciousness in the receptive mentality of others. A degree of passivity and unison of purpose in the recipient is necessary. Soon the invalid begins to think differently of himself, but though the better thought seems to be entirely his own, in reality he has been assisted. There is no hypnotic imposition, but only the calm, though concentrated, working of two minds in harmony for one result. Simply a reinforcement has been sent to where it was most needed. The "healer" has no power in his own personality, but his projected ideal, for which he is a kind of channel, is the working force. He first washes his own mind clean of discordant pictures and looks through and beyond the adverse external appearances

of the other, striving to awaken a perfect ideal that may at length be brought into expression. He penetrates to the realm from which influences are radiated outward. Gradually visible sequence and manifestation fall into line to correspond with the changed conditions at the causative centre.

A successful healer must be an overflowing fountain of love and good will. He is but a conduit, through which flows the divine and universal repletion. Pecuniary considerations must be entirely secondary. The patient's mental background is like a sensitive plate, upon which outlines of health are to be photographed.

Do failures occur? Undoubtedly, and often. Even immutable principles can have but imperfect application, because of local limitations. Among these are imperfection in the healer and lack of receptivity in the patient. Lack of immediate results often causes disappointment and leads to an abandonment of the treatment before there has been time for growth. Harmonious coöperation and transparency are necessary on the part of the recipient. But if the mind could be instantly filled with the positive ideals of health, a little time is required to change outward expression. Should such limitations discourage any one? Not in the least, for the fact that the cure is in the nature of a growth is evidence that it is normal and permanent, rather than magical and capricious. Limitations can be surmounted.

It now remains to note a few points regarding the self-application of the principles that have been outlined. This most important phase has been largely overlooked. It has generally been taken for granted that help must come from without. But outside of acute and immediately serious cases, there is a broad field for the employment of auto-suggestion and systematic concentration with happy results. When the law of self-suggestion is understood it is quite easy to utilize it, and by a little practice it becomes a powerful agency. The recorded experience of thousands shows that it is entirely practicable for one who has divined the power of idealism to gradually change his state of consciousness concerning himself. He emphasizes and intensifies his

desired ideal until he is subtly transformed by it. He claims it as already complete within, and holds it vividly, and continuously, until it presses into outward actuality. So far as is possible, he holds present adverse physical sensation in abeyance, and gradually displaces it from consciousness by a firm hold upon the perfect outline in the imaging faculty. He may mentally say to himself—even mechanically at first until the habit is formed—I (the real ego) am well, I am strong, I am pure, I am perfect, I am one with the Divine Spirit of Wholeness, disregarding adverse physical sensations. He refuses to take their testimony, for he is destroying their root. They are outwardly real, but their fountain is being sweetened and transformed. By persistently "keeping company" with his inner ideal, he gradually overcomes and corrects bodily sensation, which is only an experience of the animal plane. The concept that he is soul and not matter, if thoroughly cultivated, tends to give a needed sense of superiority and dominion over the physical economy. Such exercises in concentrative idealism are only a natural and scientific corollary of the philosophy that man is soul and not matter. Nothing could be more logical.

To ensure marked progress, special times and seasons should be set apart for the focalized thought and affirmation. Mental gymnastics are as rational and important as physical exercise. An hour or two taken from each twenty-four may be rendered profitable beyond conception. At times when the objective world, with all its cares and anxieties, may conveniently be barred out, the full glare of the consciousness is turned upon the divine ideal within, which thereby gradually becomes graphic and ruling. The mind is educated to focus itself as the ego may direct, and wavering and discordant mental habits are overcome. Increased ability to accomplish results is soon apparent in every department of life, so that even from a business, literary or scientific standpoint idealism is highly profitable. One may imagine that such an exercise would be tiresome, but a fair and continued test will reveal, not only its invigorat-

ing influence, but also its delightfulness. It is a face to face interview with one's highest possible ideals, and like other intimate friendships they soon leave their impress. Thorough concentration is a valuable accomplishment.

It may be suggested that there are those of highly developed spirituality and beautiful character who are chronic invalids, and that such facts seem to be out of accord with the principles outlined. But there are many complex elements involved. Some are highly conscientious, exemplary and lovable who are very inharmonious within. They are often subjectively in the negative conditions of fear, grief or anxiety which are strongly harmful, so there is a great lack of joyful and harmonious confidence in the *good*. Often theological or some other kind of pessimism is embittering every hour of their lives. Disquieting dogmas of the past often hang like a black cloud over sensitive souls, and such hidden causes are often concealed behind much nervous prostration and invalidism.

As related to illnesses, prevention is the end to be sought, so that in time cures may become unnecessary. Increased harmony and vigor will gradually close the subjective door to abnormity from without. We cannot afford to gaze indefinitely upon deficiency and disorder. By the immutable law of the creative force of thought we grow into the likeness of our mental pictures. Their character and quality at length become ours. Our thoughts, being our most intimate and influential neighbors, should be chosen with intelligent care.

Man is peering into the dust for new supplies of life which are only stored within and above him. Seeming ills are the reflected images of subjective misplacements. As the higher law is invoked, apparent evils dissolve and the fair proportions of the kingdom of the real are disclosed to view.

THE MISSING LINK.

By Wilson Hart.

Professor Huxley, at the close of his wonderful essay on "Man's Place in Nature," writes: "Where, then, must we look for primeval man? Was the oldest *homo sapiens* pliocene or miocene, or yet more ancient? In still older strata do the fossilized bones of an ape more anthropoid, or a man more pithecoid, that any yet known await the researches of some unborn palæontologist?"

On re-reading this not long ago an idea occurred to me that may possibly throw light on these questions. Boldly stated, without further introduction, it may be resolved into this proposition: We must look for relics of primeval man, if such exist, in that part of the globe known as the "Roof of the World"—Central Asia just north of the Himalayas. And the missing link when brought to light by the yet unborn palæontologist will prove of late miocene age.

The reasons for these rash assertions are not so glibly given. In the first place, as we have experienced no changes of climate in any part of the earth in recent years, and have made no experiments to approximate the influence of a change of climate or temperature on living organisms, change of climate as an evolutionary factor is an unknown quantity. Yet, obviously, it must be a very potent one. Frequently, indeed, it must have been the great factor in compelling changes of structure through changes of habit, or, following Mr. Mivart, in educing the latent germ life in whole species and faunas at once.

It is the change in climate of this "Roof of the World" that accompanied its elevation from sea level to some thousands of feet above it that seems to offer the most likely cause of evolution we know of.

The process of upheaving the Himalayas must have been very slow. It is probably going on now, and began in

miocene times. The change in "average weather," accompanying a shift from sea level and seascapes to a continental climate at some thousands of feet above sea level, would prove trying even in Greenland. What must it have been in a subtropical latitude? It was enormous, we know. The flora and fauna of the land subjected to such a mutation must have been altered mentally and physically from stem to stern, so to speak.

There is not very much to be added, save that Sumatra boasts at least two forms of man-like apes—Gibbons and Ourangs. And Sumatra preserves for us the fauna of ancient India more purely than the mainland. These apes are the descendants—probably not very much altered, as they have enjoyed island tropic climes—of our progenitors, who, less fortunate (!) found themselves debarred from migrating south, when it grew perceptibly colder, by a range of hills, that became higher and more impassable as the necessity of hustling for a living became greater.

So it came to pass that one branch of the family lived in slothful ease under hot suns and luxuriant vegetation, while the other struggled for generations with a slow and mighty change, until it overcame by being overcome, and on meeting again with its cousins began by worshiping them, and will finally dissect the last of them.

Two other facts are worth noting in this connection. Max Müller has declared that the Aryan race spread from Central Asia, arriving at this conclusion, after mature reflection, from a very profound knowledge of comparative philology. The other, that there are certain deposits of red, iron-stained sands and clays in India that from their fossil affinities were pronounced pliocene. This classification was unanimously held until some meddling fellow discovered undoubted human remains therein, since when these deposits have been relegated to the "Recent or Human Period;" proved such to the pious by the human relics they entombed, and allowed so, with mental reservations and misgivings, by the cautious men of science, for lack of absolute proof to the contrary.

XUM

THE PERIODIC LAW.

By Jonathan M. Wainwright.

Since the middle of the seventeenth century the basis of research into natural phenomena has been found in "Undulatory Theories." Heat, sound, and light are all proved to be forms of wave motion, and nearly all natural forces show numerous and varied instances of undulations and periodicities. Herbert Spencer says, "Rhythm is a necessary characteristic of all motion." Weather periods are well known and carefully studied by meteorologists. We figure time and regulate our calendar by the periodic motions of the sun, moon, and earth. The members of the animal and plant kingdoms, under the influence of the seasons, adopt regular periodic habits. Many of our physiological functions occur in well-marked rhythm. The pulsations of the heart, regularity of breathing, exhaustion of the muscles, and certain functions of the optic nerve, all seem to be regulated by some unrevealed harmonic forces. In fact, we find all nature filled with periodic functions, which imply some hidden law or laws. One of the most remarkable of all is the wonderful periodicity shown by the primary forms that make up matter, the very components of the earth and probably the heavenly bodies; and this has been formulated in one of the deepest and most interesting conceptions of modern science—the periodic law.

The first attempt to draw any generalizations from the atomic weights of the elements was in 1815. This was the well-known hypothesis of Prout. Prout was an English chemist and physician, and while his investigations in chemical fields were remarkable neither for number nor accuracy, he seems to have had quite a reputation as a physician (being the author of one of the Bridgewater Treatises, and the first to administer hydro-iodate of potash for goitre—a remedy which is much used at present).

XUM

It is first well to note that at the time Prout put forth his idea Dalton had founded the present atomic theory, but the atomic weights of the fifty-four elements then known had not in most cases been determined with accuracy. Prout argued that, taking the atomic weight of hydrogen as unity, the atomic weights of the other elements were multiples of that of hydrogen, *i. e.*, that they were expressible by whole numbers. From this it was but a step to consider that hydrogen was the primary form of matter, and that the other so-called elements represented different stages of combination or condensation. This theory fell to the ground after the atomic weights had been more accurately determined by Berzelius and later chemists. However, as above said, it was the first attempt to show any definite connection between the atomic weights, and created a great stir at the time, instigating greater chemists, as Dumas and L. Gemlin, to investigate the matter.

It was soon noticed that in many cases the atomic weights of certain allied elements were either nearly equal, or increased by definite increments. Thus, in Dumas's classification, he noticed that in many groups the numerical values increased by the formula A+xd, in which A is the atomic weight of the first member, and d the difference between it and the second, as:

	O	S	Se	Te
A=8	8	16	40	64 (?)
d=8	A	A+1d	A+4d	A+7d
	Li	Na	K	
A=7	7	23	39	
d=2×8	A	A+d	A+2d.	
	Ng	Ca	Li	Ba
A=12	12	20	44 (?)	68 (?)
d=8	A	A+d	A+4d	A+7d.

Wurtz, "The Atomic Theory."

In several series of three analogous elements, also, it was seen that the atomic weight of one of the members was approximately a mean between the other two, thus:

Cl 35.5	Br 80	I 127	$\frac{35.5+127}{2}=81$
S 32	Se 79.5	Te 128	$\frac{32+128}{2}=80$
Li 7	Na 23	K 39	$\frac{7+39}{2}=23$

When, however, by means of more accurate quantitative methods, the atomic weights are expresssed to two and sometimes three decimal places, the uniformity, particularly in Dumas's classification, becomes less striking, and for nearly forty years after the time of Prout's papers the various theories which arose led to no definite system.

During the decade of 1860–70 the facts which had been rapidly accumulating gave to many scientists a glimmering of the real numerical principle. In 1862 De Chancourtois, in an article to the French Academy, made a graphic arrangement of the elements in the order of their atomic weights, on a helix, and attempted to show that "simple numerical relations exist between the combining weights and all properties of allied elements." But De Chancourtois was a geologist rather than a chemist, and he did not investigate his idea further.

In 1864, however, two remarkable arrangements of the elements were made; one by Newlands, an English chemist, and the other by Lothar Meyer, Professor of Chemistry at the University of Tübingen. These two investigators found, that if the elements were arranged in the order of their atomic weights, in rows of seven numbers, those falling in the same vertical column formed "natural families," and their properties resembled each other in a more or less marked degree. These early tables were very crude, and were at first received with little conviction, and even, in some cases, with ridicule. This was particularly the case with the "law of octaves," which Newlands supported in the *Chemical News*, from 1864 onward, by many papers, some of which were full of numerical coincidences of no apparent significance whatever.

The Russian chemist, Mendeléeff, while he can hardly claim priority of idea, undoubtedly deserves the credit of having

first put the periodic law before the world in an acceptable form. This he did in an address to the Russian Chemical Society in 1869, and later in his "Principles of Chemistry," which appeared in 1871. In this he explains that "the fundamental idea which leads to the arrangement of all the elements, according to their atomic weights, is that the mass of a substance is that property on which all the remaining properties of matter must be dependent, because they are all determined by similar conditions, or by those forces which act in the weight of a substance, and this is directly proportional to the mass of a substance."

Such an arrangement having been made, it was obvious that elements having similar chemical and physical properties recur at certain definite periods. This led Mendeléeff to formulate the law as follows: "The properties of elements, as well as the forms and properties of their compounds, are in periodic dependence, or form a periodic function of the atomic weights of the elements." To explain the law, Mendeléeff has made two arrangements of the elements. In the first (Table I, Mendeléeff's "Principles of Chemistry," Vol. 1), the elements are arranged according to their atomic weights in eight groups (closely corresponding to Meyer's natural families); each group is then divided into series, from one to twelve, so that in each group the elements more closely analogous fall in the odd or even series. Thus, in Group I, a distinction is drawn between lithium, potassium, rubidium and cæsium, which fall in the even series, and sodium, copper, silver and gold, which fall in the odd series, and present only a few analogies to the members of the even series. Again, in Group II, we have beryllium, calcium, strontium and barium in the even series, and magnesium, zinc, cadmium and mercury in the odd series. Magnesium, however, like sodium in Group I, seems to have more in common with the members of the even series. Calling hydrogen the only member of the first series, the second, third and fourth are made up without interruption in either of the seven groups. After the fourth series we find three elements—iron, cobalt and nickel—which resemble each other, but cannot well be placed in any of the

TABLE I.

DISTRIBUTION OF THE ELEMENTS IN GROUPS AND SERIES.
(*Mendeléeff's "Principles of Chemistry."*)

Groups....	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Series 1....	. H	—	—	RH_4	RH_3	RH_2	RH	Hydrogen Compounds.
Series 2....	Li .	Be .	B .	C .	N .	O .	F .	
Series 3....	. Na	. Mg	. Al	. Si	. P.	. S	. Cl	
Series 4....	K .	Ca .	Sc .	Ti .	V .	Cr .	Mn.	Fe.Co.Ni.Cu
Series 5....	. (Cu)	. Zn	. Ga	. Ge	. As	. Se	. Br	
Series 6....	Rb .	Sr .	Y .	Zr .	Nb .	Mo .	— .	Ru.Rh.Pb.Ag
Series 7....	. (Ag)	. Cd	. In	. Sn	. Sb	. Te	. I	
Series 8....	Cs .	Ba .	La .	Ce .	Di .	— .	— .	— — — —
Series 9....	. —	. —	. —	. —	. —	. —	. —	
Series 10...	— .	— .	Yb .	— .	Ta .	W .	— .	Os.Ir.Pt.Au
Series 11...	. Au.	. Hg	. Tl	. Pb	. Bi	. —	. —	
Series 12...	— .	— .	— .	Th .	— .	U .	— .	
	R_2O —	R_2O_2 RO	R_2O_3 —	R_2O_4 RO_2	R_2O_5	R_2O_6 RO_3	R_2O_7	Higher Oxides RO_4

first seven groups; and copper, which may be provisionally placed in Group I. After the sixth series there are again four elements which are separate. It might be expected to find four more after the next even series, but none are sufficiently known to be so placed. After the tenth series, how-

ever, we find the platinum group. These twelve metals then, or nine as they are sometimes considered, constitute an eighth group.

Mendeléeff himself prefers another arrangement (Table II,

TABLE II.

THE ATOMIC WEIGHTS OF THE ELEMENTS—DISTRIBUTION OF THE ELEMENTS IN PERIODS.

(*Mendeléeff's "Principles of Chemistry."*)

Groups.	Higher Salt forming Oxides.	Typical or 1st Small Period.	Large Periods.				
			1st.	2d.	3d.	4th.	5th.
I.....	R_2O	Li= 7	K=39	Rb=85	Cs=133	—	—
II.....	RO	Be= 9	Ca=40	Sr=87	Ba=137	—	—
III.....	R_2O_3	B=11	Sc=44	Y=89	La=138	Yb=173	—
IV.....	RO_2	C=12	Ti=48	Zr=90	Ce=140	—	Th=232
V.....	R_2O_5	N=14	V=51	Nb=94	—	Ta=182	—
VI.....	RO_3	O=16	Cr=52	Mo=96	—	W=184	Ur=240
VII.....	R_2O_7	F=19	Mn=55	—	—	—	—
VIII.....	(.....)	.....	Fe=56	Ru=103	—	Os=191	—
			o=58.5	Rh=104	—	Ir=193	—
			Ni=59	Pd=106	—	Pt=196	—
I.....	R_2O	H=1. Na=23	Cu=63	Ag=108	—	Au=198	—
II.....	RO	Mg=24	Zn=65	Cd=112	—	Hg=200	—
III.....	R_2O_3	Al=27	Ga=70	In=113	—	Tl=204	—
IV.....	RO_2	Si=28	Ge=72	Sn=118	—	Pb=206	—
V.....	R_2O_5	P=31	As=75	Sb=120	—	Bi=208	—
VI.....	RO_3	S=32	Se=79	Te=125	—	—	—
VII.....	R_2O_7	Cl=35.5	Br=80	I=127	—	—	—
			1st.	2d.	3d.	4th.	5th.
		2d Small Period.	Large Periods.				

Mendeléeff's "Principles of Chemistry," Vol. I), in which the atomic weights follow each other in vertical columns. In this table each consecutive odd and even series constitutes one "large period," the first fourteen elements after hydrogen, however, being divided into small periods. The elements of the eighth group now form transition periods between series four and five, six and seven, and ten and twelve. By this table the periodicity of the properties is very clearly shown. Starting with lithium, the lapse of a full period brings us to the closely analogous element potassium, another period to rubidium, likewise closely related, and following at another period is cæsium. This periodicity holds good throughout, it being only necessary to follow along a full period from an element to find one which is similar in a more or less marked degree. Thus at full periods we find these three elements, the mention of one of which always calls to mind the other two: chlorine, bromine and iodine. Again, we find sulphur, selenium, tellurium, and so on.

In investigating some of the properties which show a marked periodicity, Mendeléeff's Table I is, perhaps, more convenient. The valency is a particularly noticeable periodic function. Beginning with Group I, the general formulæ for the higher oxides increases regularly from R_2O to R_2O_8 (OsO_4). The first three groups do not form stable compounds with hydrogen, but, beginning with Group IV, the general formulæ decrease from RH_4 to RH, and the analogy is borne out by the chlorine compounds, which have the formulæ RCl, RCl_2, and RCl_3 in Groups I, II, and III, respectively. The compounds with the hydroxyl radical also are regular, having the general formulæ ROH, $R(OH)_2$, $R(OH)_3$, $R(OH)_4$. In Group V, a regular hydroxide is not known, but certain salts are considered as derived from it by the subtraction of a molecule of water, as in the case of hydrate of phosphorus, $P(OH)_5—H_2O=PO(OH)_3$. Likewise in Group VI, $S(OH)_6—2H_2O=SO_2(OH)_2$, and in Group VII, periodic acid, $H_5IO_6=I(OH)_7—H_2O$. The valency evidently follows the order 1-2-3-4-3-2-1. This regularity is only general, as

the valency is not an invariable quantity, but is subject to conditions. Some elements have, in their more stable compounds, a composition which we would not expect from the periodic law, as the most common oxide of copper CuO (Cu_2O is known), and other elements have different valencies for different substances, notably sulphur—SH_2, SCl_4, SO_3.

Lothar Meyer has done very valuable work on the physical properties of the elements, in connection with the periodic law. The densities of the elements have been carefully studied, and it is apparent that, in general, the densities of the elements in a series are lower in the extreme groups, and reach a maximum in the middle. The atomic volumes which are the quotient of the atomic weights by the densities do the reverse. This can be best seen in the third series:

	Na	Mg	Al	Si	P	S	Cl
Specific gravity.	.97	1.75	2.67	2.49	1.84	2.06	1.33
Atomic volume.	24	14	10	11	16	16	27

Starting with lithium, the atomic volumes go through these variations and reach a maximum at potassium. Thence they decrease but reach a maximum again at rubidium, and another at cæsium. On this basis Meyer has made a curve showing the periodicity of the elements in graphic form. On the axis of the abscissas he has marked off distances proportional to the atomic weights, and on the axis of the ordinates distances proportional to the atomic volumes for each element. Sufficient determinations have not as yet been made to complete the curve between all the elements, but the curve as it can be drawn consists of six divisions, of which the second and third and fourth and fifth have abscissas of nearly equal length. It is extremely remarkable that the properties of elements may be determined by their position on this curve, and depend on the length of the ordinate, and whether they are on a rising or falling portion of the curve. For example, chlorine, bromine, and iodine have atomic volumes nearly equal to 26, and are all on ascending portions of the curve, about half-way to the maximum point. Manganese, iron, cobalt, and nickel are nearly equal to 7, and are

all very near the minimum point of their divisions. The same is true of ruthenium, rhodium and palladium, and the elements of the platinum group. On the other hand, magnesium and phosphorus and calcium and chlorine, while of nearly equal atomic volumes, are on different slopes of the curve in each case. On this curve the definite relations between the physical properties, ductility, malleability, fusibility, and volatility are distinctly marked.

Carnelley has carefully studied the boiling points of the elements, and has constructed a curve similar to Meyer's, it being separated into corresponding divisions; but the maxima are occupied by lithium, silicon, manganese, rhodium and osmium. Besides this, there is good reason to believe that there is with the halogens a periodic character in heats of combination, magnetic and electro-chemical properties, refraction equivalents, co-efficients of expansion and certain spectroscopic phenomena, but much is yet to be determined in these branches.

The properties of compound substances, as well, are periodic. The oxides of Group I are strongly basic, but in the following groups this characteristic decreases, and their acid quality grows stronger, until in the seventh group the oxide is decidedly acid (Cl_2O_7). The hydrogen compounds of Group VII are weaker and less stable, and so on until in Group IV the hydrogen compounds are but slightly acid, for example, HCl, H_2S, PH_3, SiH_4. The specific gravities of the oxides seem to follow the same law as those of the elements.

	Na_2O	Mg_2O_2	Al_2O_3	Si_2O_4	P_2O_5	S_2O_6	Cl_2O_7.
Sp. gr.	2.8	3.7	4.0	2.6	2.7	1.9	( )

Since the promulgation of the periodic law, chemists have been continually searching for numerical regularities among the atomic weights, and a formula devised by Carnelley for expressing the atomic weights is especially noteworthy, $A=C\,(m+\sqrt{v})$, in which A is the atomic weight, C a constant, m a number depending on the series, and v the maximum valency of the group in which the element occurs. The mean value for C is found to be 6.6, which Carnelley

believes to be closely connected with the 6.4 of Dulong and Petit.

The periodic law at its very outset demanded changes in atomic weights and valencies which had long been accepted as correct; thus the law at once exposed itself to a crucial test. The periodic law required that yttrium should be considered trivalent instead of divalent, and later researches have caused the formula Y_2O_3 to be accepted. Beryllium caused much controversy, but now careful determinations of the vapor density demand the formula $BeCl_2$, in accordance with the law. The atomic weights of thorium, uranium, cerium, iridium, and the elements of the platinum group have all been corrected from their former numbers, and now, by general agreement, are assigned atomic weights that follow the law. Oswald does not hesitate to say that, "the periodic law stands as a means of determining the atomic weights on an equal footing with isomorphism, the law of Dulong and Petit, and the law of Avogadro."

The periodic law is an invaluable instrument in the study of comparative qualities of the elements. Knowing the atomic weights, the properties of an element may be determined; and, conversely, knowing the properties of an element, its correct atomic weight may be selected from its equivalents.

The most striking demonstration of the soundness of the law was in the correct prediction of the properties of elements which were yet to be discovered. Mendeléeff's faith in his system was so strong that it led him to foretell the qualities of elements which would fill up vacancies in the tables as they then stood. Reasoning from the properties of its analogues, that is, the adjacent elements in the series and groups, he considered that the element which should occupy Group V, series 3, should have the following general properties:—easily obtained by reduction, melting point low, sp. gr. 5.9, not acted on by air, decomposes water at red heat, slowly attacked by acids or alkalis, forms an alum, oxide=El_2O_3, chloride=El_2Cl_6; atomic weight, 69, about. Four years later Lecoq de Boisbaudran discovered an

element and called it gallium. Its properties, determined by experimental research, are:—obtained from alkaline solutions by electrolysis, melting point, 30.15°, sp. gr. 5.93, not volatile, but superficially oxidized by air at red heat, decomposes water, soluble in hot HCl, scarcely attacked by cold HNO_3, soluble in KOH, forms an alum, chloride=Ga_2Cl_6, oxide=Ga_2O_3, atomic weight 69.7. With equal exactness, Mendeléeff foretold the properties of "eka-boron" and "eka-silicon," which proved to be the elements scandium, discovered by Nilson, and germanium, discovered by Winkler.

However, the periodic law is still far from perfect; there are many vacancies in the tables, and there are many analogies between elements of different groups, as well as differences between elements of the same group, that the law is unable to explain. The three sets of triplets—iron, cobalt, nickel, etc.—are made up of elements which cannot be classified properly with any of the other groups. Copper, silver and gold, while placed in Group I, are quite different from other members of the group, except in valency and ismorphism of their compounds. It is to be hoped that modern experimental methods will explain and wipe away many of these difficulties.

Professor Remsen, of Johns Hopkins University, says in a recent magazine: "The different forms of matter are in some way clearly related, and the number of elementary forms will be much reduced by investigation." It is indeed possible that further discoveries may, by reducing the number of so-called elements, place the periodic law among the many theories which have held sway in natural sciences, but are now disproved. Is it not more probable, however, that time will more closely confirm it and call for a simple revision with perhaps fewer elements, and explain the connection, which certainly exists, between substances now considered primary? Mendeléeff himself does not think that the law points to the existence of a primordial matter. With this many eminent chemists do not agree. In a fanciful but ingenious article in "Nature" (Vol. XLI), an author puts forth the idea that periodicity is due to the dependence

of each element on the typical element of its group. (These typical elements, so-called also by Mendeléeff, are lithium, beryllium, boron, carbon, nitrogen and oxygen.) He thinks that the similarity in the groups is due to the fact that oxygen is combined with the typical elements, from which, of course, it follows that they are the primary form of matter. He has compiled a table in explanation of this hypothesis, the meaning of which may be seen by citing one group:

Li 7	
$Na=LiO$ =7 +16 =23	$Rb=LiO_5$ =7 +80 = 87
$K=LiO_2$ =7 +32 =39	$Ag=Li_2O_6$ =14+96 =110
$Cu=Li_2O_3$ =14+48 =62	$Cs=LiO_8$ =7 +128=135
	$Au=Li_2O_{12}$=14+192=206

The table evidently is not exact, especially in the latter elements, and naturally has met with no support, but it is instructive as showing one line of speculation which has followed from the law.

Mendeléeff thinks that the periodicity shown by the oxygen compounds and the hydro-carbons in organic chemistry simply denote that the periodic law is capable of much wider extension. This is doubtless true, but it is of equal interest to know where the periodicity begins as well as whither it extends. If the so-called elements are not elements but compounds, and show this periodicity, it is very likely that a similar periodicity obtains in more complex compounds, but likewise in a more complicated form, which it is impossible to see at present. It is impossible that the periodicity so clearly marked can be simply accidental. It must have some cause. And is it not at least more than merely possible that our elements are incorrectly so-called, and are themselves compounded in some way from a simple form or forms of matter? Dr. Gladstone, in his presidential address to the chemical section of the British Association in 1883, said: "The remarkable relations between the atomic weights of the elements and the many peculiarities of their grouping force upon us that they are not separate bodies, created without reference to one another, but that they have been originally fashioned or built up from one another upon some general plan."

THE TESLA OSCILLATOR.

By Lieut. F. Jarvis Patten.

The fire which, since our last issue went to press, destroyed the laboratory of Nikola Tesla in this city and reduced to ashes all the recent devices of his ingenuity, has again aroused public interest in the work of this world-renowned inventor. By the creation of the rotary field motor, which now, some six or seven years from its birth, is a commercial success, and the brilliant investigations he subsequently made in the direction of high frequency phenomena—not yet so far advanced—Tesla has established his right to be regarded as the most promising inventor in electricity that we have today. It is, therefore, only natural that, when without warning all his records and more recent apparatus are suddenly wiped out of existence, the public should be eager to know what he had in preparation for his next surprise.

The so-called "Oscillator" was near to a practical working form when the fire occurred, and as this machine, in a less finished shape, had been exhibited at the Chicago Exposition, and has received a large share of his attention since that time, he has considerately given the public some photographs and details of the more advanced forms of this engine. Tesla's researches and inventions have heretofore been confined to purely electrical problems, and electricians were naturally expecting a continuation of such work, but this inventor appears to delight in surprises, and when the Oscillator was announced for the first time, the general conclusion that Tesla had contrived some way of shaking the earth's electric charge, or had made some other ultra scientific step of a like character, was far from the truth.

Of all things yet produced by him the Oscillator is certainly the most thoroughly mechanical and possibly the most practical. The term "Oscillator," in fact, was evidently selected by him in order to distinguish it from other well-known forms of vibrator, and gives hardly any idea either of the

machine itself or the functions it is designed to perform. There is, indeed, no connection between this machine and his former productions, except through the fact that its purpose is to economize the work of the steam-engine and the dynamo at the same time, and so materially to increase the output of these two essentials of every large electric generating plant, the combined weight and cost of the two being greatly reduced.

The Oscillator, in fact, is an "engine dynamo," consisting of a novel form of steam engine combined with and operating on the same bed plate a novel form of dynamo. To understand how such a contrivance can have any practical value in electric generation it is necessary first to consider the essential features of any ordinary electric plant, their relations to each other, and where any losses of power seem unavoidably to enter. In plain terms, all such plants at the present time consist of two independent parts, the steam-engine and the dynamo. This the engine drives generally by indirect methods, as it would any other piece of machinery, as a lathe or a planer, through a system of shafting and belting. True, in modern plants, where large units are employed of five hundred horse-power or upward, the moving part of the dynamo is secured directly to the driven shaft of the engine. This plan is known as direct coupling, and though it introduces no small degree of economy in operation, it seems, according to Tesla, to be only a step in the right direction. It saves, for instance, at least one unnecessary line of shafting with its attendant friction; also, the work wasted in driving the belt or gearing of some kind between the engine and the dynamo, which is a far greater useless drain upon the steam-power.

Direct coupling is, therefore, all very well, so far as it goes, but we have not saved much, if anything, in floor space, or in weight, for we have still an ordinary engine and an ordinary dynamo as before. Are there not other losses equally easy to eradicate? Every engineer knows how really imperfect the steam-engine itself is in respect to work wasted in the friction of many parts that are purely auxiliary, yet appar-

ently necessary to its operation; and although the dynamo, the much younger machine of the two, is a far less wasteful engine, there is still in every reliable form a large percentage of wire that does no work, the friction resistance of sending current through which has to be overcome. Consider the steam-engine first. Here we have a steam cylinder in which is produced the reciprocating motion of the piston rod, and this motion, which represents the active power of the engine, is next converted into rotary motion through a system of auxiliary parts, namely, the connecting rod, the crank, and the attached fly-wheel. These parts all consume work by friction, but by far the greatest loss lies in the change from the reciprocating, or to and fro, piston motion to the rotary motion of the crank, the actual power of the piston working, as it does, at every point of the circle at a disadvantage, owing to the varying inclination of the crank and piston rod in all positions. Rotary motion once obtained, however, we have to reconvert a portion of it back again through further auxiliary apparatus—the eccentric with its rods and valves—to the reciprocating motion of the valve in the steam chest, which latter by its great friction, due to the steam pressure, wastes no inconsiderable amount of power. Thus we see that in the steam-engine all the apparatus except the piston and steam cylinder are auxiliary to it, and all waste, or use up without doing any work on the shaft of the engine, some of the energy delivered by the expanding steam to the piston head. In fact, it is plain that our conversion of the reciprocating motion of the piston to the rotary one of the fly-wheel is wasteful, and if done away with a considerable saving of power could be effected.

Unfortunately, however, in all the machinery for which the steam-engine has been heretofore used as a motive-power or driver, the rotary motion was required in the apparatus, and was, therefore, made in the steam-engine which drove it; all machinery, in fact, with very few exceptions, being essentially rotary.

On the other hand, if we examine the dynamo we shall find that we have made the dynamo a rotary machine only

because the steam-engine is, and to accommodate it to the latter. The dynamo had to be driven by a steam-engine, and in its evolution was naturally first made rotary in order to adapt it to existing forms of the steam-engine.

It is well known to electrical engineers that the simplest and most economical forms of dynamo have reciprocating parts only, and that the rotary form can only be contrived at a certain loss of efficiency. We may, therefore, state in general terms that the usual form of engine, rotary, is not adapted to the best form of dynamo, while the best type of engine for driving the simplest and most economical form of dynamo, that having a reciprocating motion only, has not yet been contrived or designed; not because of any inherent difficulty in the designing of such an engine, but simply because such a machine has heretofore had no particular sphere of usefulness.

The Tesla Oscillator is revolutionary in this respect, that it reverses the existing forms of engine and dynamo construction by making them both reciprocating in their action, thus coupling an efficient dynamo to a steam-engine, which, being also reciprocating, has no wasteful auxiliary parts, and no wasteful conversion of the original reciprocating motion to the rotary form of motion. Such, in general terms, is the Tesla Oscillator. It aims simply at a higher economic construction of the two essential parts of an electric generating plant, and in formulating this idea Tesla makes one machine of the two on one bed-plate, and thus again makes no little saving of space and weight.

While this construction, as described for sake of simplicity, might seem easy at first glance, a few engineering difficulties of a purely mechanical character soon become evident that render the solution of the problem one of extreme difficulty.

Briefly stated they are as follows: The dynamo to be economical requires an extremely high rate of to-and-fro motion, say at least eighty to one hundred strokes a second, while the steam-engine, on the other hand, owing to its necessarily heavy parts, requires a very slow rate for a dyna-

mo, say ten strokes a second, and these adverse requirements of the two machines must somehow be reconciled.

Again, the conversion to rotary motion in the steam-engine from the reciprocating form through the medium of the crank, serves a very useful purpose, especially in the case of heavy and powerful engines. This connection of the piston to the crank causes the piston to start up slowly under the enormous pressure of the steam, attaining its highest speed only for an instant about midway of the stroke, then slowing gradually down to the end of the stroke, where it is zero. The piston is then ready to resume its backward journey in the same manner without shock or jar to the structure. We thus see that there is at least one compensating feature in our conversion loss, for it would evidently be impossible to send the heavy piston, weighing, perhaps, a thousand pounds, at full speed from one end of the cylinder to the other, then instantly arrest its motion at the exact point and send it back again at the same rate. To do this a few times a second would be certain disaster, but to do it at a high rate of speed would be as certainly impossible. In the Oscillator the piston travels its journey to and fro a hundred times a second, and can go much faster if required, but the mechanical conditions are all different. In the first place, the parts are all small and extremely light, it being claimed that an engine of a given power on this plan can be made about one-fortieth the weight of an ordinary engine of the same power; secondly, the piston stroke is very small, being in no case more than a fraction of an inch; and, finally, automatically operated air cushions, or springs, are used, that serve to check and slow down the motion of the piston gradually at the end of the stroke.

In one form of the Oscillator two pistons are used that go out and in the opposite ends of the same cylinder at the same time, thus balancing the motion and relieving the apparatus from the rapid shock of vibration. Like the engine having two pistons the dynamo is double, or rather there are two, one for each piston, each of which carries a light armature that it rapidly thrusts into and withdraws from a very in-

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tense magnetic field. The vibratory form or oscillatory form of dynamo is not essentially new. Several earlier laboratory machines having been made this way, perhaps the most remarkable of which was the Edison tuning-fork dynamo, remarkable chiefly, however, for its utter inapplicability to any use.

Perhaps the most remarkable feature about the Tesla apparatus is a novel system of steam packing introduced, which enables him to use a steam pressure of three hundred and fifty pounds without any perceptible leak. This, taken in conjunction with the very high rate of piston speed used, which, of course, only compensates for the very short stroke, should produce an engine of high economy. As for the dynamo, the type certainly admits of high economy in construction, and it is claimed that in one form there is absolutely no armature wire that is not cutting lines of force and doing work.

While it is too early to predict the eventual outcome of such revolutionary steps in both steam and electrical engineering, the developments thus far seem to have been of the most encouraging sort.

THE OPEN COURT.

Comments on Articles in Previous Numbers of the Review.

History Repeated.

Sir Isaac Newton and Leibnitz. — *Professor Dewar and Olszewski.*

C. J. M.

The paper "Scientific Irritability," in the April number of this quarterly, dealing with the recent Argon controversy, shows to what lengths ignorance, with "base envy which hates that excellence it cannot reach," can carry its resentment in scientific circles; where, by the laity, a different state of things has supposed to reign.

Some American journalists, in mentioning this article, have made the mistake of attributing the course taken by one man of science toward Professor Dewar, as the action of the British Association, thus giving a wrong interpretation of the censure meted out, with no unsparing pen, upon the antagonistic Cambridge originator of the shameful charges.

Those who followed the correspondence in *Nature* and read the papers in *The Philosophical Magazine* on this subject, could not fail to have been reminded by Professor Olszewski's course, in endorsing and reiterating such unfounded statements, of Newton's experience with Leibnitz, which is a matter of history.

Throughout this unwarranted aggression, the distinguished resident physicist of the Royal Institution has maintained the same calm, dignified attitude toward his adversary, that characterized Sir Isaac Newton when Leibnitz made public his unfounded charge. It was not until King George I had instituted inquiries as to when Newton's answer to Leibnitz would appear that Newton wrote his long explanatory letter to the Abbé Conti, triumphantly refuting the allegations of Leibnitz, who had affirmed that Newton had stolen his method of fluxions, and that the English wished to pass for almost the only inventors.

Sir Isaac gave, in this letter, facts and dates—as Professor Dewar has done in his lectures—which entirely disproved his assailant's charges, closing with these words: "Mr. Leibnitz complains of the committee of the Royal Society, as if they had acted partially" (with partiality?) "in omitting what made against me; but he fails in proving the accusation. For he instances a paragraph in it concerning my ignorance, pretending that they omitted it, and yet you will find it in the *Commericum Epistolicum*, page 547, lines 2 and 3, and I am not ashamed of it. He saith that he saw this paragraph in the hands of Mr. Collins, when he was in London the second time,

October, 1676. It is in my letter of the 24th of October, 1676, and therefore he then saw that letter. In that letter, and in some other letters writ before that time, I described my method of fluxions, and in the same letter I described also two general methods of series, one of which is now claimed from me by Mr. Leibnitz."

The letter of Sir Isaac concludes with these lines: "But as he has lately attacked me with an accusation which amounts to plagiary, if he goes on to accuse me, it lies upon him by the laws of all nations to prove his accusations, on pain of being accounted guilty of calumny. He hath hitherto written letters to his correspondents full of affirmations, complaints and reflections, without proving anything. But he is the aggressor and it lies upon him to prove the charge."

In 1831, David Brewster, LL.D., F.R.S., in his "Life of Sir Isaac Newton," says: "In viewing this controversy, at the distance of more than a century, when the passions of the individual combatants have been allayed and national jealousies extinguished, it is not difficult to form a correct estimate of the conduct and claims of the two rival analysts."

But Professor Dewar did not have to wait for another century to exonerate him from the charges brought against him; for, in his recent course of lectures, he has rehearsed the occasions when he had given, in past years, full credit to Cailletet, Pictet, Olszewski and to the late Professor Wroblewski, in their order of low temperature research, all of whom had been impeded by want of safer and better apparatus than any that existed up to 1886, when Professor Dewar overcame certain of the preceding difficulties. More recently, by his invention of a storage vessel with a vacuum jacket, he has held liquid gases in larger quantities than they were ever held before, while pursuing his investigations on a much more extended scale than had been possible for any experimental researcher to do up to that time, even to the extent of liquefying hydrogen, as is surmised, although not yet announced.

It was the writer's privilege to be in the laboratory of the Royal Institution on the day when Professor Dewar first tested the invention which conquered the difficulties which he, in common with all researchers in low temperatures, had been forced to contend with. The success was perfect. It is well known that the chief scientific use of liquid gases consists in the facilities given for the study of the properties of matter at a state approaching the zero of absolute temperature; but until Professor Dewar's invention, no vessel had been found in which a liquid gas could be held long enough for such purpose without great loss from rapid evaporation.

With the exception of the determination of the refractive indices of liquid oxygen, Professor Dewar's work has had nothing in common with that of Professor Olszewski, who, with as

scant courtesy as that shown by Leibnitz to Newton, said: "The experiments of Professor Dewar are merely the repetition and confirmation of my researches." To this charge Professor Dewar replied: "Reviewing the work I have been engaged upon during the last few years, either by myself or in consort with Professors Liveing or Fleming, the following subjects have been taken in hand, and so far developed with regard to the properties of matter at low temperatures:

"Construction of Apparatus for the Production of Liquid Air and Other Gases in Quantity—High Vacua—Vacuum Vessels for Storage and Manipulation of Liquid Gases—Cooling by Sponge of Liquid Air—Solid Air—Radiation at Low Temperatures—Thermal Transparency—Refractive Indices—Spectroscopy—Electric Conductivity—Thermo-Electric Properties—Latent and Specific Heats—Capillarity—Chemical Action—Magnetic Properties—Breaking—Stress of Metals—Solid Matter and *Argon* in Liquid Air—Phosphorescence and Photographic Action—Liquefaction of Hydrogen, &c. With the exception of the determination of the refractive indices of oxygen, my work has had nothing in common with that of Professor Olszewski.

"Now Professor Olszewski says he has anticipated all this pioneering work. On referring to his list of papers, given in *The Philosophical Magazine* for January, I find that since the year 1890 he has confined his attention to the refractive indices of liquid oxygen and an attempt to corroborate Professor Wroblewski's determination of the critical contents of hydrogen. No one knows better than myself that the fringe of the subject only is yet touched. When the investigator has the means of examining the general properties of matter under new conditions, surely in our time he does not claim originality for the selection of the order in which he attacks the many problems ready to hand. The fact is, the claims set forward by Professor Olszewski are fantastic and unfounded.

"Professor Olszewski has done good work in the determination of the pressure and temperature relations of the liquid gases, but in future it is to be hoped that he will modify his claim for general priority in everything relating to low temperature research."

Royal Institution, February 14th, 1895.

La Morale D'Une Découverte.—Under this heading the Paris *Le Figaro* comments upon Lord Rayleigh's discovery of a new gas in our atmosphere, which element it pronounces to be "good tempered, as evidenced by having allowed itself to be crystallized, forming a new mineral called clevite."

"All vegetables, all animals since the beginning of the world," continues *Le Figaro*, "have breathed the argon and ignored the clevite without enfeebling their constitutions or their intelligence. Where, then, comes in the importance of the discovery? one is tempted to ask.

"But, on reflection, it is not as frivolous a discovery as it seems to be, for it emphasizes a lesson which men of science need to learn! Imagine the reception, up to the date of this discovery, that would have been given to a candidate for a bachelor's degree if, when asked the composition of the terrestrial atmosphere, he had permitted himself to express one doubt that its constituents were not exactly those which science had, up to that time, decreed them to be.

"Would not the examiner have replied: 'How can you doubt what you have been taught? Science alone possesses the knowledge which enables it to promulgate its canons with absolute certainty. The immortal works of Priestley, Lavoisier and Dumas give us the exact composition of atmospheric air—oxygen, azote and traces of watery vapor. Nothing more and nothing less.'

"But if this third constituent exists, we see that what was until now held as scientifically accurate is no longer so, and that science is compelled to change her dogmas to suit the theories of her wise men as they advance in knowledge of the laws of nature. In modifying her doctrines, science, like religion, approaches nearer to the central truth, the source of all truth; and the knowledge that it is so should predispose their followers to be less dogmatic than they are. Mutual toleration is the only safe path for churchmen as well as men of science to pursue if they wish to retain their influence. One man, armed with a single physical fact, is enough by himself to overthrow forever the concensus of mankind and the revered opinions of mighty men. One fact proves stronger than human wisdom. A Galileo or a Magellan outweighs a thousand generations.

"However, in regard to the discovery cited, not all chemists are yet convinced that this new gas is an element. They reason that, as it is not yet proved to be a simple nor a compound, it may turn out to be a substance."

This brings us to *the moral of the discovery*, as handled by *Le Figaro*. "*Voici que les certitudes d'aujourd'hui ne sont plus celles de demain. Le parti le plus sur est la tolérance mutuelle, qui voudrait que la science respectât la foi, puisque la science ellêmeme a si souvent besoin d'être crue sur parole.*"

H. O. Ward.

REVIEWS.

TEXT-BOOK OF COMPARATIVE GEOLOGY, By E. KAYSER, Ph.D. Translated and edited by Philip Lake, M.A., F.G.S. (Macmillan & Co., New York.)

Treatises on geology are far too apt to be confined to the phenomena of a single country, while the remainder of the world is dealt with in a very cursory fashion. This is due to the fact that writers who have original observations to describe have usually made them within narrow limits, and have little personal acquaintance with the conditions existing elsewhere. The method is an imperfect one, however. The geological formations of no locality are complete, and the key to the problems found in one region may exist in a far distant district. Comparative observations are, therefore, invaluable. It was, for instance, from observations made in the Rhenish mountains that Mr. Ussher was able to comprehend the geology of South Devonshire, and numerous examples of the same fact might be adduced. Hitherto, however, there has been no text-book in the English language that offered adequate aid in such comparisons. The present work seeks to supply the desideratum, so far, at least, as the geology of Europe is concerned. The work of Dr. Kayser, Professor of Geology in the University of Marburg, though intended for use in the schools of Germany, devotes considerable attention to the formations of other countries. This useful beginning has been worthily carried forward by Mr. Lake, who, in his translation, has made important additions descriptive of the geology of the extra-German countries of Europe, thus obtaining the advantage of comparative presentation so far as that continent is concerned. Only brief attention has been given to the geology of the other continents, the limits of space not permitting a broader treatment. As it stands, however, this work will be found to take a valuable step in the desirable direction of comparative geology. The subject is treated historically, from the Archæan age downward, the description of the rock formations of each geological period being followed by brief statements of its palæontology. It is illustrated with numerous plates of fossils.

INTRODUCTION TO THE STUDY OF PHYSIOLOGICAL PSYCHOLOGY, By THEODOR ZIEHEN. Translated by C. C. Van Liew, Ph.D., and Otto W. Beyer, Ph.D. Second edition. (Macmillan & Co., New York.)

It has been a natural outcome of the development of science that psychology has ceased to stand alone, as a science *sui generis*, and that its many close relations to physiology have in a measure combined the two into a single science. Research has been turned in this direction for

several decades in Germany, and the physiology of the nervous system shown to bear such affinities to mental activity that they could no longer be properly considered apart. Brief as has been the history of this new science of physiological psychology many new lines of investigation have been opened, and two distinct and largely conflicting schools have arisen, known respectively as the school of Wundt, and that of Ziehen and Münsterberg. The doctrine of apperception, characteristic of the former school, and which is offered as an explanation of many difficulties, is considered superfluous by Ziehen, who declares that all psychological phenomena can be explained without this assumed principle. This work is small in size as compared with that of Wundt, and even with that of the American author Ladd, but it embraces within its compass all the essentials of the science, and seems excellently well fitted to serve as an introduction to advanced study and experiment in this field. The author treats his subject as one of the natural sciences, clearly and sharply defining its province and fixing the limits which divide it from the other natural sciences. He aims throughout to employ only physical or physiological data in his explanations, and applies the laws of evolution steadily in his consideration of the presence and activity of the several functions of the mind.

A TEXT-BOOK OF SOUND, BY EDMUND CATCHPOOL, B. Sc.

A TEXT-BOOK OF MAGNETISM AND ELECTRICITY. Second edition. BY WALLACE STEWART, D. Sc. (W. B. Clive, London, Eng.)

The two works here named form part of "The University Tutorial Series," designed originally for use in the University of London, but adapted to a much wider field of employment. They constitute respectively Volumes I. and IV. of "The Tutorial Physics," of which Volumes II. and III., on *Heat* and *Light*, are also by Mr. Stewart. The whole forms a very useful aggregate of treatises on physical science, intended for the use of candidates for matriculation, intermediate science and preliminary science examination. The treatment is strictly elementary, and these works will, no doubt, be found valuable as an elementary introduction to the study of physics. They have the advantage of being up to date, a considerable one in the case of sciences whose rapid advances render it difficult to keep abreast of discovery.

JOHN DALTON AND THE RISE OF MODERN CHEMISTRY. BY SIR HENRY E. ROSCOE, D.C.L., LL.D., F.R.S. Price, $1.25. (Macmillan & Co., New York.)

Professor Roscoe here adds to the "Century Science Series" a very interesting and instructive biography of one of the leaders of English scientific discovery. John Dalton's name, though usually spoken of only in connection with his theory of chemical atoms, is known to scientists in connection with other valuable discoveries, of which that of "color blindness" is sometimes termed "Daltonism" in his honor. The son of

a poor handloom weaver, of Cumberland, England, he showed unusual mathematical powers early in life, and at the age of twelve was already acting as school teacher, having pupils several years older than himself. He continued to teach during most of the remainder of his life, most of his years being spent in Manchester, where he taught private classes long after he had gained an European renown.

Mr. Dalton possessed an earnest love of investigation, devoting himself particularly to meteorology and chemistry, in which sciences he made long series of observations and experiments, often with apparatus of the crudest kind—old ink bottles, home-made thermometers and barometers, small and simple balances, etc., aiding him to attain results few of which have been invalidated by later research. While experimenting much he read little, committing the error of not making himself familiar with the work of others, and thus, to some extent, duplicating former experiments and attaining known results. The atomic theory was wrought out by him in the early years of this century, and first made public during a course of lectures at the Royal Institution in the winter of 1809–10. It has served to simplify chemical science to a remarkable degree, and has given to the poor Cumberland school teacher a world-wide fame.

GOD'S IMAGE IN MAN. POLITICAL ECONOMY OF NATURAL LAW. IDEAL SUGGESTION THROUGH MENTAL PHOTOGRAPHY. EDWARD BURTON. BY HENRY WOOD. (Lee & Shepard, Boston.)

We have here four works by one author which economy of space obliges us to present together. This we do the more willingly, since Mr. Wood has saved us the necessity of any extended notice by his paper in this number of THE REVIEW, in which he clearly indicates the general character of the psycho-medical doctrine which forms the general subject of several of these books. This doctrine bears a resemblance to what is known as Christian Science, though Mr. Wood designates his system as "mental healing," and treats it in a more comprehensible fashion than that of its usual presentation. That the mind has a considerable degree of control over the body, and can often influence its action curatively, is widely known and acknowledged, and this power may very well be capable of greater extension than it has hitherto displayed. The facts of hypnotism prove that in many cases the mind of one person can control the mind, and through it the body, of another. This is as far as most of us are prepared to go, but Mr. Wood argues forcibly that, by what he calls "Ideal Suggestion," a much deeper and wider influence of mind over body can be acquired, and the powers of mental healing be much increased.

"In Edward Burton" this subject is pleasantly treated from the standpoint of fiction. "Political Economy of Natural Law" is a treatise of quite different character, as its title indicates. Mr. Wood here briefly and intelligently deals with a wide field of social and industrial relations, in what is necessarily a generalized manner, but which presents much matter for thought on some of the most mooted and difficult of modern questions.

XUM

A HANDBOOK OF SYSTEMATIC BOTANY. BY DR. E. WARMING. TRANSLATED AND EDITED BY MR. C. POTTER, M.A., F.L.S. Price, $3.75. (Macmillan & Co., New York.)

Dr. Warming, who is Professor of Botany in the University of Copenhagen, here gives us a most valuable treatise on Systematic Botany, whose merit has been added to by Dr. E. Knolbauch, who revised the classification of the *Fungi* in his German translation, and by Mr. Potter, whose English translation is from the third Danish edition (1892), to which he adds, in an appendix, the successive classifications of plants. This work has long been recognized as an original and important contribution to systematic botany, and in its present form may claim to be the latest word on the subject treated. So far as botanical system is concerned, it is one of the best works extant; the classes, orders, and families of the plant world being given, as closely as possible, in their natural developmental succession, and succinctly but clearly described, in language adapted alike to the student and the general reader of botanical science. The work contains more than six hundred well-drawn illustrations, showing the characteristic parts of the various orders, and adding greatly to the elucidation of the subject.

A STUDENTS' TEXT-BOOK OF BOTANY. BY SYDNEY H. VINES, M.A., D.Sc., F.R.S. Price, $2.00. (Macmillan & Co., New York.)

Professor Vines, who is Sherardian Professor of Botany in the University of Oxford, has written this work on the basis of the English edition of the late Professor Prantl's *Lehrbuch der Botanik*. He has not, however, confined himself to the text of Prof. Prantl's treatise, but has, while retaining all its features of value to young students, extended its scope so as to adapt it also to the use of advanced students. His additions, indeed, have been so voluminous as to double the number of pages, particular attention being given to the section on the Classification of Plants, which he has very considerably extended. The work, therefore, while retaining the general form of that of Prof. Prantl, is essentially new and distinct, and justifies the claim of Prof. Vines to its authorship. In addition to the revision of the old and the introduction of new matter, the illustrations have been added to, there being now four hundred and eighty-three in all. This work differs from the one just considered in embracing the whole field of botany in its treatment, including a full and satisfactory handling of classification. It must prove of much value to botanical students generally.

MAGNETISM AND A NEW COSMOGRAPHY. BY GEORGE W. HOLLEY. (Arena Publishing Co., Boston.)

This work is not easily reduced to classification. It is a sort of composite photograph of electricity, optics, astronomy, biology, psychology, spiritism, and other subjects, yielding a countenance which the author offers as that of magnetism. Unfortunately, the likeness is unrecognizable, and actual magnetism is especially notable for its absence. The New Cosmography is dealt with in the same unsatisfactory fashion. Mr.

Holley evidently has not had the education of a scientist, and wanders far too widely from his point to please the scientific taste, though his work may please those who enjoy discursive writing, and are not particularly interested in magnetism or cosmography.

A CONFESSION OF FAITH. (MacMillan & Co., New York.)

Under this title an unorthodox believer gives to the world a brochure that presents his belief in a manner which can never offend the most orthodox of believers. It is the work of a religious man, a thinker and a scholar. The writer believes in God, and takes the ground that nature moves between two poles or ideal opposites—spirit and matter. Spirit is the real or positive, matter is the apparent or negative, pole of existence. Common sense tells us so. Which is the higher form of energy, the material energy of an athlete's limbs, or the spiritual energy of a poet's soul? What materialism sees behind the veil of outward things is the void and formless infinite. What religion sees behind it is the power and glory of the spirit of God. God is love, and he that dwelleth in love dwelleth in God and God in him. Love is in itself ideal truth. Reason can decipher the detailed mysteries of material nature. Love alone can comprehend the all-pervading mystery of God. These are some of the leading points of the "Confession of Faith" of one who regards love as the highest conception of religion; but when the writer proclaims that knowledge of ultimate realities—exact, certain and scientific knowledge—is unattainable by man, he falls into the same error that science has adopted and taught.

Absolute truth is not to be dreamed of, the author asserts, limiting his ideal of truth to the possibility of its comprehension by the human mind; but minds not content to reject *à priori* knowledge, or to rest on a system based upon experience and induction, will reject this empirical teaching, and claim that He who spake as never uninspired man spake was divinely empowered to proclaim that the spirit of truth would lead *His followers* into all truth. In other words, the true spirit of science will lead mankind into exact, certain and scientific knowledge, as they prepare themselves to receive it, or are prepared by the disciplines of life.

As has been said of Christianity, so may it be said of science: "Being a perennial vine it is ever yielding new wine."

The designs of the Creator, writes Gilman, have required millions of ages to carry out. They are so vast and complex that they can only be realized in the sweep of ages. One design is subordinated by another without ever being lost sight of. These designs involve an infinitude of effort, often ending in what, to our view, looks like failure, to be crowned, after a series of ages, with complete success at last.

In this long chain of physical causes, writes Dr. Wilcox, seemingly endless, but really commencing with that one link which touches the hand of Him who made all matter and all potencies that dwell within matter, this cosmical activity has been ceaseless, these cosmical effects numerous past conception, by which universal nature has slowly unfolded and become the universe of to-day.

Thus Christianity and science together are progressively revealing the laws of nature, as the human mind is fitted for the reception of truth. Although

truth never changes, yet as an absolute thing existing in and by itself it is relatively capable of change, for as the atoms hold in their tenacious grasp undreamed of potencies, so truth holds germs potential of all growth. Every new truth withheld until the progress of humanity requires its revelation, unfolds just what is needed to enable mankind to reach a higher plane of knowledge.

In illustration of this remark let us admit that Professor Lascelles-Scott, Physicist in the British Government Laboratories, Forestgate, Essex, was right when he announced, in THE NEW SCIENCE REVIEW of October, 1894, that "it is futile to insinuate a doubt, or venture upon a sneer, as to the virile influence of sympathetic vibration;" that Keely is simply developing and immensely extending a power already known; what, then, should have been the result in order for this age to answer its own demands? It would seem that, as this physicist writes, "Keely has been (as to several of his statements) confirmed, and even anticipated by others. Fact upon fact in this direction is proved up to the hilt on evidence of the most absolutely indubitable sort. Even the suspension of the force of gravity, respecting which Keely has been subjected to much ridicule, is shown to be possible, and, indeed, easy of demonstration."

Such an announcement ought to have been of sufficient weight to have caused researchers, on the same line, to examine for themselves; to prove all things and hold fast to the truth; but those learned men who were conversant with Keely's claims, as a discoverer of an unknown force of nature, found his theories "unintelligible and inconsistent," and preferred to have commerce witness the proffered demonstrations and decide as to the financial value of Keely's system of aerial navigation. By this course science has lost the opportunity of enlisting such services as Nikola Tesla and Edison might have rendered by turning their attention to "the sympathetic field" in their researches, for Keely has found no time to experiment with electricity, and much remains yet for him to do before his great discovery—the greatest ever made—can be acknowledged as of commercial value, whereas science could now, if she would use her powers, make known its worth to the cause of progress and humanity. Keely has been the first "to plunge through the deep and broad questions surrounding the mechanism of the universe, prosecuting his investigations until he has attained a mechanical explanation of all things;" proving by demonstration the unity of matter and the simplicity of the laws by which God works His wonders to perform.

It is obvious enough to the reader of "A Confession of Faith" that one tenet of its writer's creed is "Nature is not an aggregate but a living whole." In this belief he is prepared for the new philosophy; but he is altogether astray in rejecting what he calls the supernatural, which is really nothing but natural law working ever above our present limitations of knowledge regarding its operation.

This assertion is on the point of being demonstrated to the world as an actuality in so plain and indisputable a fashion that those who have stood aside with cold indifference, or have gone farther yet, and have stigmatized Keely's philosophy as false and chimerical, will have to confess their blindness, and be forced to testify to the existence of a force unknown to them of incalculable practical value.

H. O. WARD.